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ARTHROSCOPY OR THE DIRECT VISUALIZATION OF JOINTS

An Experimental Cadaver Study*

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INTRODUCTION

The idea first occurred to us in the latter part of the year 1929 that it might be possible to see the interior of joints directly through a proper instrument introduced into the joint. In February 1930, we consulted with Mr. Reinhold Wappler concerning the construction of an instrument for this purpose. An instrument was devised according to our particular requirements. At that time, Mr. Wappler told us that he had not heard of any instrument for such a purpose, nor had he ever made any similar instrument. We first began work in March 1930 in the Anatomy Laboratory of the New York University Medical School, through the kindness and interest of Dr. Harold Senior, Professor of Anatomy. Material being so limited then, we were asked by Dr. Senior to delay further work until autumn of the same year, at which time a greater abundance of material was sure to be available. In September 1930, however, we sailed to Europe, and it was not until February 1931 that we again resumed work in the Pathologic Institute of the Krankenhaus der Friedrichstadt-Dresden, through the great courtesy of Dr. Georg Schmorl. The following is a complete report of the work done both in New York and in Dresden.

It was not until we had completed our work that we were informed that Bircher had preceded us. Priority should be awarded to him, since his work was done in 1922. A brief survey of the high lights of his work, which was incidental to his study of meniscal injuries, is necessary. He used the Jacobaeus laparoscope in a joint filled with oxygen or nitrogen gas. On the basis of a few cadaver experiments, he believed that only the knee joint was suitable for examination. He reported twenty clinical cases

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which were examined through his instrument, with the findings subsequently confirmed by operation. He saw changes in the meniscus (such as hemorrhage and tears), osteochondritis of the femur, and synovial tuberculosis, etc. In a foot-note, he says that he examined fifteen other cases, in addition to the twenty described. His work does not seem to have received any support. In 1925, in a speech in Holland, Bircher again affirmed the value of this endoscopy of the knee joint, especially in the diagnosis of meniscal lesions*.

We have also received word from Dr. Leo Mayer that Dr. H. Finkelstein and he have also been working on this same problem, during a period of time coincident, in general, with our work.

The term "arthroscopy" is self-evident, and everyone to whom the idea is mentioned coins the term spontaneously. It is thus natural to designate the instrument as the "arthroscope". Bircher called the process variously "endoscopy of the knee joint", "arthro-endoscopy", and "arthroscopy".

DESCRIPTION OF THE INSTRUMENT

The accompanying illustration shows well the construction of the instrument. Mr. Wappler has kindly furnished the following brief description: "The arthroscope consists of a sheath with a point serving as a trocar. An extremely small lens system with illuminator fits within the said sheath. It permits visualizing of narrow spaces either air or water filled. The removal of the telescope permits washing out of opaque fluid contained in hollow bodies to be examined, until the distending fluid is clear and a good view can be had. The front lens is shaped so that the inlet pupil is on the periphery and the little lamp on the end is just on the outside of the field of vision. It has been found that this is the only way of obtaining the smallest dimensions for a useful illuminable lens system."

The diameter of the trocar is four millimeters and that of the telescope three millimeters. Note should be made of the space between the trocar and the telescope, which allows irrigation of the joint examined. The faucets are attached to the trocar and may be used either as an inlet or as an outlet. It is usually better to use intermittent irrigation, though constant irrigation ought to be used in washing out the joint until the fluid return is clear, if the joint is filled with pus or blood. Since it requires some moderate force to distend a joint, the distending agent should be introduced with a syringe, until adequate distention is obtained; then irrigation used, either intermittent or constant, as the case may be. It is inadvisable to use soft rubber tubing, since it will blow up with the force required to distend the joint.

A few points in regard to the care of the instrument should be emphasized. It is absolutely necessary to keep the lens system clear. Often, during an examination of a joint, the front lens becomes fogged, either by

*A few days before receiving the proof of this article, we discovered a brief article by Kreuscher on arthroscopy[9]. The author describes his instrument but does not comment on its use.

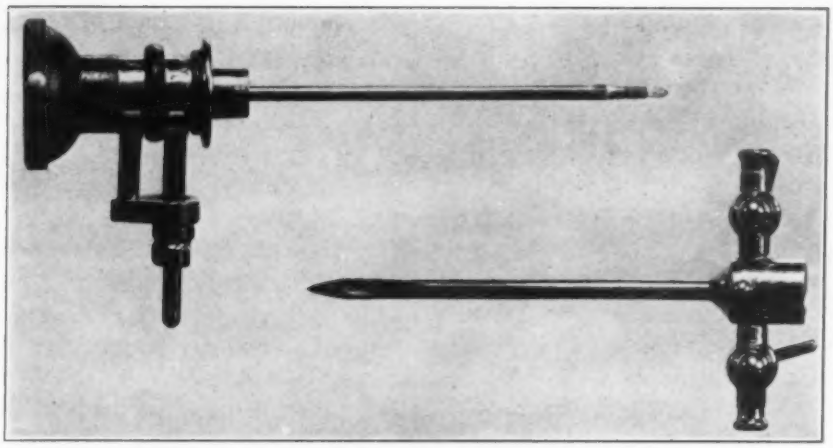


FIG. 1

The arthroscope divided into its two component parts; the upper is the telescope and the lower its sheath or trocar. (The illustration shows the arthroscope three-fourths actual size.)

synovial fluid or fat, or even blood or pus. A mixture of synovial fluid and water is sometimes oily, and may soil the lens, which can be cleaned with a toothpick dipped in alcohol. The eye piece should be scrupulously clean too. The lens system should be thoroughly tested as regards clearness and definiteness of vision before use, and it is advisable during a routine examination to cleanse the front lens at least once or twice. The sheath or trocar is easily kept clean and sterilized. A three to four and a half volt battery is used to furnish the power for the lamp, an ordinary house current being too strong for the instrument and too dangerous for the patient. The strength of the battery should be tested weekly. We have also used a resistance arrangement thrown into the circuit to dim or increase the brilliancy of the light. The electrical connections should be well tested before using, so that a proper brilliancy of light is obtained, usually at about three volts. The lamp sometimes throws a glare, when it may give high lights on a polished surface,—such as cartilage; this, at times, makes it difficult to tell fine color details. In this case the light should be dimmed. With a higher voltage, so much heat is given out by the lamp that it becomes difficult to hold it in the hand; although, in a joint distended with fluid, the lamp should cool quickly. There is slight danger of burning anything in the joint, since the heat is so quickly diffused through the fluid medium. If the lamp is poorly constructed and projects above the surface of the trocar, there is a possibility that it may break off into the joint, especially if the joint is narrow or if the lamp encounters a solid obstacle. In our experience this once happened in the elbow joint. With a well fitting bulb that is below the level of the oblique opening of the trocar, there is no danger of breaking the lamp. An instrument, such as the Jacobaeus instrument for laparoscopy, with the lamp free in the joint cavity, should never be used,

since the lamp may be broken off easily, even on gentle movement of the joint. For the best vision of a particular area, the lamp should be some distance away from it—not directly on it. As the needle is inserted, one notes that one can see somewhat ahead of the path of the entering needle; when the needle is withdrawn, the path by which it is withdrawn is also seen.

If the trocar is bent, as has happened, one's field of vision is partially interrupted by the interior of the trocar protruding itself on the visual field. Straightening the trocar will quickly restore the entire field of vision. We were once puzzled for several days by this, but when the matter is recognized it is easily remedied. It is very doubtful if, in moving a joint gently, the trocar can be broken, since it is constructed of strong steel.

When the telescope is inserted into the trocar, the white knob on the telescope should be on the same line as the opening for the lamp. It is then that a full field of vision is obtained. The terms of the clock have been adopted for indicating the position of the lamp, when the telescope is so placed, since this is simpler than expressing it in degrees,—thus, twelve o'clock means that the lamp is facing upwards, etc. The telescope does not magnify a field of vision but shows a larger area for examination, reduced in size. It is possibly worth while, after a particular area has been located for examination, to use a lens system which magnifies. When looking at a distant object through the eye piece—such as the side of a wall—a very large area, embracing many meters, may be seen. As the telescope approaches the object examined, the object becomes larger and larger, to the exclusion of a large part of the original field. The object seen is nevertheless always much reduced in size, though easily recognizable. If the telescope, contained within the trocar, is held perpendicular to a sheet of printed paper, one can see a circular field with a radius of about one-half inch;

PLATE I

A and *B*. Views of two different hip joints of adults. Anterior paratrochanteric puncture used. Hip in external rotation, slight abduction, and neutral to flexion or extension. In both these cases, only a small part of the joint space is seen, with fat projecting into it. The neck of the femur with its ridgings, the junction between head and neck, and a part of the head are seen. More of the superior and upper surface of the neck is shown.

C. A view of the wrist joint through the usual dorsal puncture. The lower end of the radius, a large part of the scaphoid, and a small part of the semilunar bone are seen. Note particularly the intercarpal joint between the scaphoid and semilunar bones, communicating with the main wrist joint cavity.

D. View of the shoulder joint of a child through the usual anterior puncture. Note the head of the humerus, the glenoid fossa with its outlying ring or labrum of fibrocartilage. The origin and course of the long head of the biceps should be noted.

E. Shoulder joint of an adult through the anterior puncture. Views *E*, *F*, *G* are all taken from the same case. The long head of the biceps is seen as it courses through the darkish joint cavity.

F. A part of the head of the humerus.

G. A view of the glenoid fossa. The origin of the tendon of the biceps is not indicated.

A

B

C

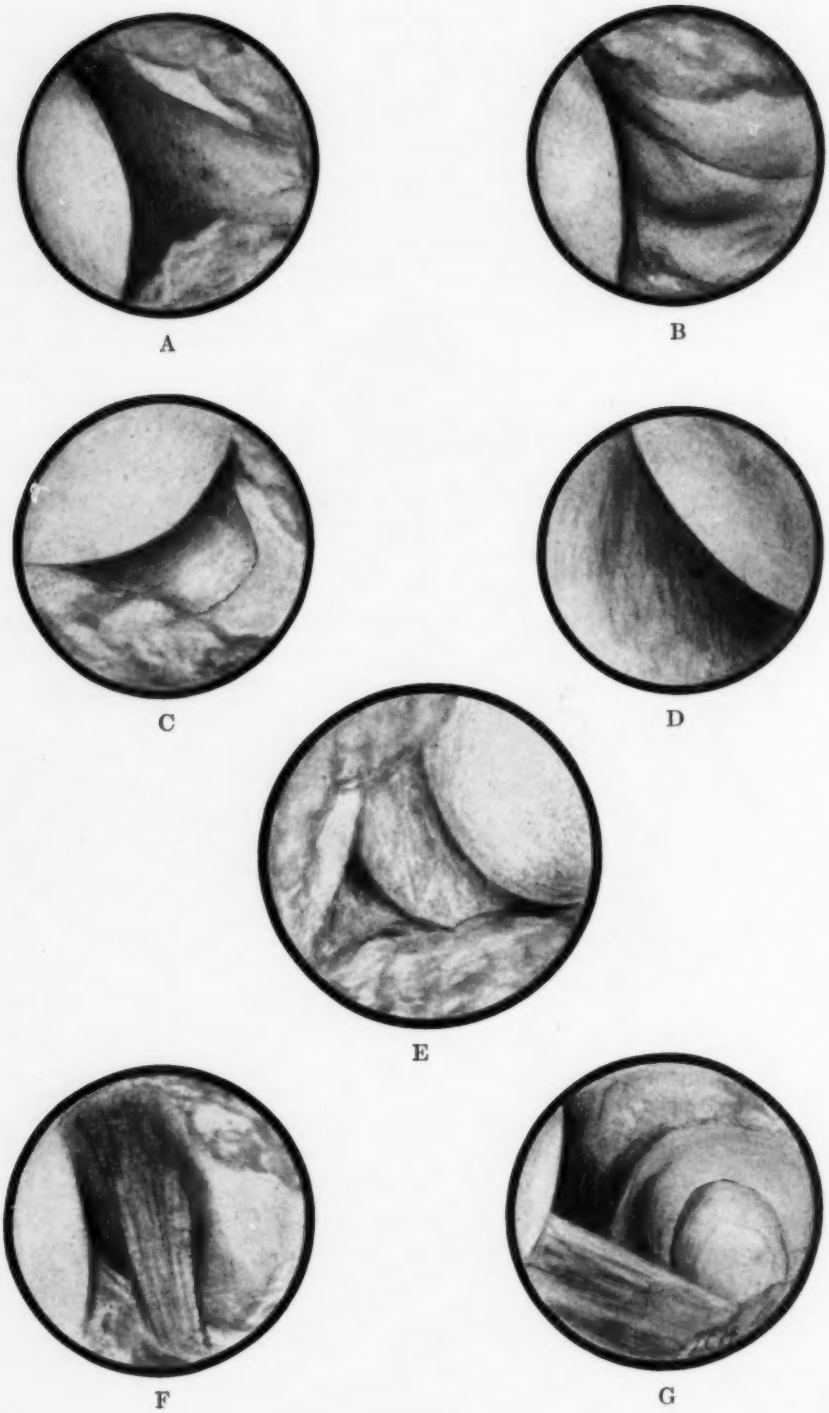
D

E

F

G

PLATE I
(See page 672)



A B C D E F G

PLATE II
(See page 675)

PLATE II

A. Medial puncture of the knee, knee extended to 170 degrees. Patella above, covered in part by overhanging fat. Part of external condyle shown in field. Joint space shows its typical grayish color. Fat pad below.

B. Lateral puncture of the knee, knee flexed at 100 degrees. Note the internal meniscus which is well delimited here. A good part ot the superior surface of the tibia is shown. The internal condyle of the femur rests on the meniscus, which curves behind it. Yellow fat is seen obscuring vision of the region of the tibial spines.

C. Medial puncture of the knee, knee flexed to about 100 degrees. The external meniscus, resting on the external surface of the tibia, is clearly outlined. The external condyle of the femur is well seen, especially in its rounded lower end.

D. Posterior puncture of the knee with the knee extended to about 170 degrees. The posterior internal compartment of the knee is seen, with the posterior part of the internal condyle projecting into it.

E. Lateral puncture of the knee, knee extended to 170 degrees. Both condyles of the femur are seen well, one behind the other, the external condyle being in the foreground. The patella is seen moderately well, though some of its under surface is obscured by fat. Fat of the capsule and of the infrapatellar pad block further view.

F. Medial puncture of the knee, knee flexed to 90 degrees. The region of the intercondyloid fossa is seen, with a good view of the anterior crucial ligament, as it arises from the inner aspect of the external condyle of the femur. The posterior crucial ligament can just be made out. The insertion points of the crucial ligaments are not made out in this view. Parts of the condyles of the femur are also seen.

G. Medial puncture of the knee, with the knee at 90 degrees of flexion. Needle pointed downward. An unusual view showing the external meniscus almost in its entirety. A good part of the superior surface of the tibia is seen. A small part of the internal condyle of the femur may be noted, with the anterior crucial ligament behind it. The external condyle of the femur is not seen, though its position is just indicated. The region of the intercondyloid fossa also is indicated.

with the telescope unsheathed it is less. It will be noticed that the letters are somewhat optically distorted, those in the center being larger and longer, and fading out peripherally into smaller letters, reduced in size, but more normal in shape. Chromatic aberration is not present.

After an examination, the instrument is cleaned, and the lens system and lamp again tested. Sterilization of the instrument is the same as for the cystoscope. To prevent water injuring points of electrical contact, a special wax, prepared by the makers of the instrument, should occasionally be used.

We have had some difficulty in procuring lamps that will burn brightly for a reasonable length of time. Many of them have not burned more than two hours of intermittent use. Possibly this may be because of the delicacy of the metal filament, or because the current required to light it well is too strong; yet, our current has seldom exceeded three volts. With the resistance arrangement in circuit, more current passes, so that a dim bulb may be made lighter.

It follows as a natural corollary that, as in the case of the cystoscope, an operating arthroscope for the removal of synovia for biopsy examination should and can be developed. The ends of the average laboratory forceps grasping tissue can be seen easily, and there is space enough in the sheath to remove adequate biopsy specimens. We have seen a large piece of fat pass

out from the joint through the trocar after puncture. It may also be possible to develop an attachment to push away fat. We can then combine the diagnostic and operating arthroscope into one instrument.

GENERAL PRINCIPLES OF ARTHROSCOPY

When it occurred to us that a potential space—such as a joint cavity—might be filled so that an actual space resulted, then the first principle of arthroscopy had been determined. *Distention*, by a non-irritant fluid—such as distilled water, boric acid solution, physiological salt solution—or by a non-irritant gas—such as air, oxygen, or even carbon dioxid—creates an actual joint space, into which the visualizing apparatus may be inserted. Theoretically and practically, fat is the greatest obstacle to good vision and, therefore, the distending agent must be strong enough to push the fat away from the things to be seen. To separate joint surfaces, so that a greater space results, *traction* is necessary. This traction also separates fat pads in contact with structures to be visualized. Manual traction is best and varies in direction and force with the joint to be examined. Reyher noted that, with the use of average man power, plus a force of one hundred pounds, the condyles of the knee joint could be separated only three and five-tenths millimeters; a force of forty pounds separates them one millimeter. We do not know of any other exact experimental observations on this subject, but, in the course of this work, we have noticed, empirically, that in cadavera the amount of joint separation by traction depends directly on the musculature and ligamentous apparatus of the joint, and possibly on air pressure. The more emaciated and weak-muscled the cadaver, the greater is the separation. Individual joints vary. This applies particularly to the shoulder joint, where, in some cases, we were able to separate the joint surfaces even up to one-half inch. This is more likely to take place in the shoulder joint with a relaxed capsule and a flabby musculature, the tendon of the long head of the biceps humeri apparently offering no resistance. We have not been able to separate the apposing surfaces of the hip joint, and a separation does not seem likely after studying the anatomical structure of the joint. In the knee, traction does give a slight advantage to visualization; but, in the average adult, we doubt if the apposing surfaces can be separated more than a few millimeters. The strong attachments of the crucial and lateral ligaments effectually prevent good separation of the joint surfaces. In the child, however, a good separation can be effected sometimes. In the wrist, traction does increase joint space, sometimes even as much as one-eighth to one-quarter of an inch, depending on the relaxed state of the wrist. An arthritic wrist usually does not allow much or any separation by pull. We have not been able to accomplish any separation in the ankle; and in the elbow, when it is strongly flexed, the effect of traction is almost negligible.

Position of the joint noticeably determines better or poorer visualization. Correct position, combined with the factors of distention and trac-

tion, plus the use of a proper technique, render good visualization of a joint easy. The proper position for the various joints will be discussed respectively under the joints considered. It is to be emphasized that *traction* is used in the line of position of the limb. At times, one may use *pressure* to bring certain structures into better view,—as pressure behind the head of the tibia to bring out the superior surface of the tibia, pressure before or behind the head of the humerus, etc. At times, it is also advisable to use *motion*, either of rotation, or of flexion and extension, to orient us or bring out certain structures better. In moving the joint, while the arthroscope is within it, all motions must be made slowly and gently, in order to avoid injury to joint structures and to the instrument.

Puncture of the joint should be done carefully, so that the large trocar does not tear away cartilage or bone, nor injure soft tissues. Cartilage may be quite easily grooved, especially in the narrower joints, if one is not careful. We have had this happen a few times, and, since cartilage shows so little regenerative power, such an unfortunate accident possibly might be the beginning of an arthritis or the formation of a loose, cartilaginous body in the joint. However, if cartilage is removed, most of it is generally carried away in the deep groove of the trocar, in which the electric lamp lodges. There it appears as whitish or grayish, flaky strips. We stress this damage to the cartilage, since it is not an unlikely accident. Rough handling of the trocar within the joint may cause hemarthrosis of the joint, with a possible tendency to the formation of secondary adhesions.

ARTHROSCOPY OF THE INDIVIDUAL JOINTS

We have examined more than ninety joints,—about forty knee joints, about twenty hip joints, about twenty-five shoulder joints, four wrist joints, and two or three ankle and elbow joints. In every case, we have compared our findings as seen through the arthroscope, with those seen when the joint has been opened. The joint was also examined through a capsular puncture in many cases, after the skin and subcutaneous tissues had been cut down to the capsule. We thus double-checked our findings as seen through the arthroscope by the usual skin puncture.

The joints of children are generally seen in their entirety in one field of vision; those of adults in several.

The joint to be examined was distended with water, which was introduced under moderate force by a syringe. When the needle is in fat, it is difficult to distend the joint. If the capsule has been punctured through and through, the joint may not fill well, since the fluid passes out into the soft tissues.

One should be careful that air is not introduced, when distending the joint with water, since air bubbles obstruct and distort vision. Air bubbles are spherical, blackish in color, and with a polished surface, reflecting high lights. The bubble moves with the motion of the joint, can be pushed up and down, and can be punctured by the trocar. An air bubble may be large

enough to cover the entire field of vision. The danger of air embolism, though very slight, is to be considered.

A bloody fluid appears as uniform red and is easily recognized.

1. *Shoulder Joint*

The structures that can be seen in visualizing the shoulder joint are: the head of the humerus up to the anatomical neck at the site of capsular insertion, the entire glenoid fossa with its ring or labrum of encircling fibrocartilage, the origin and course of the long head of the biceps tendon, as it passes through the joint above the head of the humerus. The joint space is a definite space of some considerable dimensions, into which fat and synovial villi project in varying amounts.

We have used both the anterior and the posterior puncture of the shoulder, of the type described in the text-books. Both punctures are easy, though the anterior one may possibly injure the cephalic vein. In using the posterior puncture, we have not seen the biceps tendon, since this is in the upper anterior part of the joint. The posterior puncture is as effective otherwise. When the puncture is made, the limb is held in about seventy to eighty degrees of abduction and in some external rotation, traction being made strongly downwards in the line of position of the limb. It may be necessary to steady the neck by counter-resistance. The joint is then filled enough so that water spurts back through the trocar; the telescope is then inserted. With the anterior puncture, we once noticed the filling of the bicipital groove on the arm, when the joint was distended; the needle may have been in the biceps tendon or in its encircling vagina mucosa intertubercularis, that extension of the synovia which surrounds the biceps tendon in the joint. The anterior part of the joint is seen at its widest when the arm is strongly rotated externally and abducted to about one hundred degrees; the posterior part of the joint, when the arm is internally rotated and less abducted. It is not always necessary to approach the limits of rotation. As one first looks in, one may see nothing but a yellowness, indicating that one is in fat. The trocar is moved gently up or down until an actual view of the joint space is seen. One can always be sure that one is in the joint proper when water spurts back through the trocar. The joint space is usually grayish black in tone, with a reddish tint or glow of the lamp. Fat, either in strands or in compact pads, may be seen to encroach on the joint space, and even partially obscure cartilaginous surfaces. One usually sees dimly the inferior part of the capsule in the depths, through an anterior puncture.

The head of the humerus, when the needle is turned towards it, is seen in the field of vision as a section of a sphere (the needle being at nine or twelve o'clock); and when the cartilage is normal, the surface is a gleaming white, with sometimes a bluish tint beneath the white. Rotation verifies the fact that we see the head, and increase or decrease of traction may separate or approximate the head in relation to the glenoid fossa. The

posterior and inferior surface of the head is seen best by a posterior puncture, and, with rotation, especially internal rotation, most of the head can be seen. In arthritis, the cartilaginous surface is not as shiny as normal, less white, even grayish, with the gleam lost, and zones of erosion may be seen. In one case, grooves made in the cartilage by the trocar were well seen. The glenoid fossa is usually seen in its entirety, though it may be sometimes covered partially by fat. Its relative smallness, as compared with the head of the humerus, is well observed. The needle should face at three o'clock (right shoulder) or at nine o'clock (left shoulder), with the lamp opposite the center of the glenoid fossa. The entire fossa, including its outlying labrum, can then be inspected. The cartilaginous covering of the glenoid fossa does not appear as gleaming white as that over the head of the humerus. The origin of the biceps tendon is easily determined, and the tendon can be traced over the head of the humerus until it leaves the joint. It is not possible in every case to see the tendon, since the upper part of the joint is often covered with fat and synovia which conceal it from view. The tendon appears as a band about one-quarter to three-eighths of an inch wide, glistening yellowish white (yellowish because of the light of the lamp), passing through a grayish joint space. The color contrast is strong. As the arm is bent at the elbow or extended, one notices the movements of the biceps tendon. When the arm is under traction so that the biceps tendon is stretched taut, with the arm in moderate abduction and external rotation, flexion of the elbow relaxes the tendon so that it curls on itself. Extension of the elbow tightens it. When pathological changes, especially those of an arthritic nature, are present in the joint, it may be difficult to see the biceps tendon, since it is easily covered by hypertrophic and hyperaemic fat. It should be traced from the glenoid fossa.

In general, it may be said that the shoulder joint is the easiest and most consistent of all joints to visualize.

2. *Wrist Joint*

We have seen the wrist well, though, at first, we thought the wrist joint unsuitable for examination, since the joint is narrow and the trocar relatively wide. A practical difficulty also offered itself in that we were not permitted to dissect the wrist, and even puncture of the wrist had to be done by special permission, since the upper extremity is not touched in the routine autopsy. Our experience is limited here to four punctures and no dissections. We, therefore, chose those wrists that allowed good traction, especially those with flabby musculature. The wrist was palmarly flexed and put in strong ulnar deviation to increase the dorsal joint space, and strong traction applied in this direction, with necessary countertraction at the elbow. The joint was punctured dorsally at the usual puncture site, and enough water injected so that a swelling appeared on the dorsum of the wrist, and water spurted back through the needle.

The structures which may be seen are: most of the articular end of the radius, the articular space with fat and synovia in varying amounts, the intra-articular parts of the scaphoid and semilunar bones (more of the scaphoid than of the semilunar), and the joint space between the scaphoid and semilunar bones, communicating with the main wrist joint cavity. The inferior carpally directed ends of the scaphoid and semilunar bones are not seen. The discus articularis of the ulnar-carpal joint is not seen. In a normal joint, the cartilage over these bones is a gleaming white and the fat is a normal yellow. In an arthritic joint, the cartilage is less white,—more grayish and opaque. Injected fat and synovia may obscure vision.

Though our experience here is not large, still it is certain that the wrist joint can be definitely visualized, although a narrower trocar with a less oblique opening at its end is preferable. The opening should be smaller and less oblique, since the joint is so narrow anteroposteriorly that the point of the trocar and half of the opening may be in the joint and the other half in subcutaneous tissues, or even in open air, in which case nothing can be seen. Vision is not only of the wrist joint but also of the intercarpal joint between the scaphoid and semilunar bones.

3. *Hip Joint*

A study of the hip joint shows that it is impossible to separate the head of the femur from the acetabulum. Visualization of the hip joint is limited to the intracapsular part of the joint. It is manifestly impossible to insert a needle between the head of the femur and the acetabulum. One cannot, therefore, hope to see the acetabular fossa with its outlying horseshoe-shaped fibrocartilage (the so called facies lunata), the incisura acetabuli, the ligamentum teres, or the part of the head of the femur about the fovea capitis femoris that is always in the joint, even in rotation. Neither can the space between the head of the femur and the upper acetabular rim be seen, since it is covered by fat and capsule. What one does see is a good part of the head of the femur, the junction of the head and neck of the femur, and the entire intracapsular part of the neck of the femur. The joint space and its fat, and sometimes even the capsule, though not the zona orbicularis, can be seen also. With external rotation a larger part of the head is seen and more of the neck than in any other position of the femur; in internal rotation, the head passes into the acetabulum, leaving but a small part of it visible. More of the inferior and lower part of the neck of the femur is seen in external rotation; in internal rotation, more of the superior and upper parts of the neck. It is not necessary to use much abduction and in most cadavera we have found it difficult to move the joint because of rigor mortis fixing the joint solidly. The joint was usually in slight abduction, in a position neutral to flexion or extension, and could be rotated. No traction could be used.

We experimented with a number of punctures and the anterior paratrochanteric puncture proved best. The anterior or anterior oblique puncture, with the obliquity directed inwards and downwards to a space just at

the junction of the head and neck of the femur at its inferomedial part is unsatisfactory; it is a difficult puncture to do, and vision is easily obscured by fat, so that little can be seen. By this puncture one expects to see only a part of the head and a part of the lower and inferior surface of the neck of the femur. Practically, we were always sure we were in fat and were doubtful if we saw anything besides fat. The posterior paratrochanteric puncture is not good; it is more difficult than the anterior one, and the needle passes through a great mass of resistant muscle.

The anterior paratrochanteric puncture is undoubtedly the best and is made slightly anterior to the greater trochanter, along the general course of the neck of the femur, until the head is touched. With a little practice, one can soon tell just where the needle is, and even localize with the point of the needle the junction between the head and neck of the femur. The puncture is not hard to do and one can visualize the hip joint with it in almost every case. Originally we were skeptical as to whether anything could be seen in the hip joint, but we have had unusual success with this puncture. We have been careful to choose cadavera of slender build, since our trocar is not long enough to puncture the hip of a well muscled person. The rim of the acetabulum is about seven centimeters below the skin, and the center of the acetabulum about nine or ten centimeters below, in a direct anterior puncture; for the anterior paratrochanteric puncture, the needle should be at least fifteen or more centimeters in length. A special long trocar, with a correspondingly long telescope, should thus be used for the hip joint. The line of the femoral artery and the position of the head of the femur should be marked beforehand to avoid possible damage to the vessels. This should be only a theoretical accident.

The joint is now distended with water, not much being required, until a return spurt indicates fulness and tension within the joint. The telescope is now inserted, and, with the needle at about nine o'clock (for the left hip), one sees the neck of the femur, with its fine and coarse ridges, coursing obliquely upwards to meet the head. The junction between the head and neck of the femur can be more or less well defined, and the nutrient foramina moderately well seen at times. A fair part of the head of the femur is seen, varying in amount with the rotation of the femur. We have always been able to see the superior and upper surface of the neck of the femur well, but the lower and inferior surface less so, since these seem to be out of the visual field and obscured by fat. The joint space is well seen, a gray color at times, though more reddish usually from the glare of the light. Into it projects fat, either compactly arranged in pads or as loose, free, floating villi, more or less transparent. The capsule itself may be seen as more whitish than the fat. In one case, puncture of the hip joint was done, the joint examined and found normal. On withdrawing the needle a gush of pus came out, which on subsequent examination proved to arise in the soft tissues of the inner aspect of the thigh. The hip joint was free of pus.

It is to be emphasized that it is not at all difficult to see into the hip joint and that it is the neck of the femur which here commands our interest.

4. *Knee Joint*

We come now to a really complex joint, the visualization of which offered most difficulties at first, but we have finally evolved a technique which seems excellent and allows practically free visualization of the entire joint. The knee joint is well supplied with fat, either compactly arranged in pads, or spread more diffusely, or in a finer villous formation. Since the lens or lamp can be blocked by a small piece of fat, it is most important to keep out of the fat. The question of proper puncture and position are very important here. Through the usual medial or lateral infrapatellar puncture, one invariably finds the needle embedded in the infrapatellar fat pad or in the fat pads connected with it, such as the semilunar fat pads so well described by Fisher. One sees thus a yellow or yellowish red, more or less uniform mass of tissue, and nothing else. We have tried many different types of punctures with the idea of avoiding this fat and we believe the following technique good: The needle is inserted at about the lower third of the patella, directly lateral or medial to it. It may be inserted even lower, at the level of the lower part of the femoral condyles, though this puncture has not always been successful. The knee is held at about 170 degrees of extension, when the puncture is made, and the needle can be felt free of fat, beneath the patella. If the knee is flexed before puncturing, the mass of fat, protruding in the knee joint and under some tension because of the position of flexion, invariably blocks the lamp. The joint is distended easily in the extended position, until water spurts back. We have been considering whether or not it is wise or useful to fill up the quadriceps bursa, since such a large cavity holds so much water uselessly. In one case, the quadriceps bursa was ruptured, because of the great tension of water within it. In some cases, then, a cloth has been wrapped tightly about the upper part of the knee, over the bursa, to prevent its distention. We do not think that this improves visualization, but it means less tension in the knee joint.

Vision is begun with the knee extended. One sees the joint space well here, or at least the upper part of the space, and with the needle at twelve o'clock, or facing upward, one observes the under surface of the patella, and even the vertical ridge dividing it. There may be a horizontal ridge at times. Sometimes, one does not get a complete view of the under surface of the patella, since it is covered by overhanging bundles of fat, more solid and diffuse than usual. The patella may also be seen in profile. One can see also the femoral condyles, usually in their upper parts, but not in their rounded lower ball ends. One may get a profile view of the condyles, one behind the other, with the intercondyloid fossa indicated as a deep shadow between them. The patellar articulating surface on the femur may also be seen. The fat pads connected with the infrapatellar fat pad are seen pressing ovally into the joint, one behind the other, when viewed from the side. Pressure over each half of the infrapatellar fat pad causes these to project deeply into the joint cavity, and even to occupy all that part of the

joint space visible, while release of pressure or stronger counterpressure over the quadriceps bursa pushes these fat pads away from the joint. Pressure and release of pressure over the patella will cause the floating patella to be seen to bob up and down. The quadriceps bursa is not visualized. For the examination of this bursa, a radio-opaque material should be injected into the joint and the joint x-rayed. We do not recommend lipiodol, on the basis of our clinical experiences with it.

The knee is gradually bent now to about ninety to one hundred degrees of flexion, very gently and slowly; usually not much more is seen during this motion of the knee. At this position of flexion the needle should be faced between six and nine o'clock on the left side, and from three to six o'clock on the right side. Views opposite to the indicated positions show only fat, either of the capsule or of the pads. The inner surface of the infrapatellar fat pad is smooth and may resemble the superior surface of the tibia, in many indefinite markings on it. The ligamentum mucosum and its accompanying fat, the so called alar folds which usually divide the knee joint incompletely into halves, are seen. In an arthritic joint, with proliferation of synovia and the formation of adhesions, division may be complete. The needle then may be in the joint space but be lost in fat, preventing vision. The needle usually passes much under the region of the ligamentum mucosum and no difficulty in vision is encountered. We have been able to see the ligamentum mucosum several times, and, in two cases early in our work, with the needle pointed strongly upward to the region of the intercondyloid fossa, so that the needle made an acute angle of thirty to forty degrees with the knee joint, we saw the ligamentum mucosum as a broad, thick, whitish band, resembling a strong band of adhesion. We have also looked down on the ligamentum mucosum through a puncture in the mid-patellar region, medially placed. The ligamentum mucosum shows a variable development and will not always appear the same; its location however is constant. In arthritis, it becomes grayer, more opaque, with indefinite edges, and hyperaemia may be present. The conversion of it into scar tissue undoubtedly caused it to appear as the thick, white band mentioned above.

It is noted that through an internal or medial puncture, only the outer half of the joint is usually seen, and *vice versa*. This is explained by the fact that on withdrawing the needle gradually, as from a medial puncture, one sees not the inner half of the joint, but a wall of fat which arises from the medial part of the capsule, blocking all vision; this is not always true but is so in most cases. It should be remembered that fat is a variable factor within a joint, lest these statements seem contradictory. A study then should be made of all these fat pads and their changes noted. We have noted hyperaemia, hypertrophy, atrophy, color changes, etc. The synovial villi may be increased, irregular, or hyperaemic. Rarely does one see a transparent villus with a distinct blood vessel coursing through its center.

With a medial puncture, at the site indicated above, and with the knee flexed as mentioned, with pressure at times behind the head of the tibia to

push the superior surface forward, and with traction exerted in the line of position of the limb, one sees practically everything in the joint,—not in one single field of vision, but in several. In the knee joint of a child, the entire joint can often be seen in one field of vision. The region of the intercondyloid fossa is first explored and the inner part of both the internal and external condyles of the femur examined. The usual erosion at the top of the intercondyloid fossa may be noted and, sometimes, the presence of exostoses, though these are difficult to determine. One notes that fat of the fossa may partly obscure vision of the crucial ligaments, though they are well seen usually. Early in our work we were doubtful whether or not one could see crucial ligaments, but since then we have seen them so often and so well that the matter is established beyond doubt. The anterior crucial ligament usually is seen best and can be followed from its fan-shaped origin on the inner surface of the external condyle down to its insertion on the tibial spine. A distinct blood vessel on its medial aspect may be a good guide to it at times. With the joint opened and the knee strongly flexed so that the heel almost touches the buttock, we see the anterior crucial ligament taut and extending beyond the limits of the intercondyloid fossa; with the knee less flexed, as at one hundred degrees, the ligament is relaxed and disappears into the fossa. We have not verified this with the arthroscope. We have noted with the arthroscope, however, that, in a child, with the knee moderately flexed and the femur fixed, the anterior crucial ligament was not taut in that position, and that on external rotation of the tibia the ligament became more slack, and, on internal rotation, very taut. In one case, in which the point of the trocar was caught in the relaxed anterior crucial ligament, in the usual position of flexion, movement of the trocar could be seen to stretch the ligament taut or to relax it. The posterior crucial ligament can be seen in part, but not as well as the anterior crucial ligament. Its insertion is not seen. Although the tibial spines are usually not clearly visible, we have seen them well several times. They are often concealed by fat.

One also notes the femoral condyles in all their roundness and one can follow them from about the upper part of the fossa to their rounded end on the tibia. With the medial puncture, one sees the external condyle well. The internal condyle is less well visible, though it can be seen. With touch experience with the trocar, one can say that the needle is touching a particular part of a condyle, or the intercondyloid fossa, or the region of the meniscus.

The needle now is pointed downward toward the superior surface of the tibia, with the knee still in the same flexed position and the needle at six to nine o'clock (left knee—reverse for right knee). The external meniscus of the tibia is then seen well and its free edge outlined as a sharp concave line, or often as an irregular more or less frayed line. The superior surface of the tibia, seen medial to the external meniscus, is usually not as clear a white as the condyle of the femur, and it is therefore more difficult to see areas of erosion on it. The meniscus disappears posteriorly as it

curves behind the external condyle of the femur, which rests partly on it, but pressure from behind the tibia may bring it sharply forward so that it can be followed to its insertion. Rotation of the tibia on the fixed femur may also help in bringing it into better view. The insertion points of the meniscus are not always seen well, since, as has been mentioned, the region of the tibial spines is fat-covered. The meniscus may be touched by the needle and be made tighter or looser, if it has enough natural give. Changes in the meniscus can be seen and the normal color changes should be remembered: in the young, a white—the equivalent of young cartilage; and with age, a more yellowish and more opaque color. Cuts and fracture lines can be well seen in the meniscus, as we determined it once experimentally. In one case we were able to recognize an abnormally shaped meniscus, which covered the entire surface of the tibia, and which was somewhat kidney-shaped and seemed to have a thick reddish inner border. This was verified on opening the joint. The tibial spines have been discussed. The rough area between the spines can not be seen.

The joint space, it should have been noted, is grayish or even blackish, and into it project fat and synovial villi.

Through an external or lateral puncture, one is able to see the inner half of the joint. The inner meniscus can be seen well and any changes in it noted. The posterior crucial ligament is usually not seen, nor is the intercondyloid fossa as clearly seen as in the medial puncture. This may be due to the fact that the external condyle juts out more than the internal and that, therefore, the fossa is set back, out of good vision. The internal condyle is well seen, and changes in it, such as arthritic erosions, or color changes in the cartilage, are seen quite well. The tibial surface is seen lateral to the inner meniscus, but not as clear as the femoral condyle.

In one case, through a medial puncture, we examined a knee joint that had been arthrodesed because of tuberculosis. The patella had not been fused and the resultant small joint space, between the under surface of the patella and the concave surface of the arthrodesed bone, was examined through the arthroscope. This peculiar joint space was easily distended. Fat was seen to be of a dark brownish color, and a grayish fibrous tissue was seen over the arthrodesed bone. The patella showed some arthritic changes. The findings were verified on opening the joint. No trace of the original disease was present and a longitudinal section of the excised knee showed perfect fusion of bone.

For the examination of the posterior compartments of the knee, both lateral and medial, we have had recourse to posterolateral punctures, medially or laterally placed. The knee was held in moderate extension and the needle inserted anteriorly to the posterior tendons of the knee joint, hugging the condyle at its lower level. In a joint filled previously from an anterior puncture, it becomes very easy to puncture the posterior compartments properly. One knows that the needle is in the joint space by a return gush of water. There is no danger of injury to the popliteal vessels, since the needle is anterior to them and does not reach the mid-line of the

popliteal space. The line of the popliteal vessels can be marked out before puncture and the distance calculated on the needle to prevent injury to the vessels. The text-books do not describe puncture of the posterior compartments of the knee joint and we are not aware that such a puncture has been done before. We have found this puncture so easy that we do not hesitate to recommend it, especially if the joint has previously been filled with water by an anteriorly placed puncture. It is necessary to make two punctures to examine both posterior compartments. The rounded, posterior parts of the femoral condyles up to the capsular insertion may be seen well. The joint space is grayish or blackish and a varying amount of fat is present. It is not possible to see the posterior half of the intercondyloid notch or a posterior view of the posterior crucial ligament, since they are outside the joint cavity. We have not seen the menisci through a posterior puncture.

It is theoretically possible that a suppurative arthritis of the knee may be treated by four punctures of the knee, simultaneously placed, two anterior and two posterior, unless the pus is blocked off by adhesions which can not be reached by the needle.

In one case, puncture directly through the ligamentum patellae was tried, but only fat was seen. Were no fat present, this might be a good puncture, since one should see both sides of the joint through the same puncture, and almost in one field of vision.

The knee joint is thus eminently satisfactory for arthroscopy, though it requires at least two punctures for complete visualization. Examination of the posterior compartments should not be a routine measure unless indicated.

5. *Ankle Joint*

This joint is not suitable for arthroscopy. The joint space is so narrow that even a very thin needle can not be inserted into it. We have not been able to obtain any separation of the joint surfaces by traction. We have examined one formalin-fixed ankle joint, and two or three ankles of cadavera, recently deceased. The foot is usually held in plantar flexion so strongly that we have not been able to mobilize it. Anatomically considered, one should see through an anterior puncture most of the superior surface of the astragalus, and part of the articulating surface of the lower end of the tibia. One cannot expect to see the malleolar articulating surfaces, since we cannot look over the curved surface of the astragalus. The anterior puncture was made directly lateral to the extensor tendons, at the usual puncture site. It should be noted that the fibular side of the joint is narrower than the tibial side. There is no danger to the dorsalis pedis artery, but it is not possible to avoid injury to the joint, and an extensor tendon may be pierced through. A posterior puncture or a posterior oblique puncture is not feasible. In order to increase the posterior joint space, we have held the foot in strong dorsiflexion, after cutting the ligaments about the ankle and the tendo achillis and the fat pad in front of

it. Even then, it was practically impossible to get the needle in the ankle joint. The posterior part of the articulating surface of the astragalus may be seen and part of the tibial articulating surface when the joint is so dissected. Possibly, in the living patient, with a very thin needle and a small telescope, one may be able to do something with the ankle.

6. *Elbow Joint*

This is another of the large joints unsuitable for examination, since the joint space is so narrow for the relatively large needle. The anterior puncture of the elbow is out of the question and the posterior puncture poor for our purposes. We have not tried a puncture directed horizontally beneath the olecranon, because it was impossible to go under the olecranon with our large needle. We were only able to examine two or three elbow joints, arthroscopically and by dissection, since the upper extremity is not touched in the usual autopsy routine in Dresden. Other anatomic material was not available. The posterior puncture must be made lateral to the olecranon process, since the ulnar nerve runs about the medial epicondyle of the humerus, in the narrow space medial to the olecranon. Considering the anatomic possibilities for visualization in this posterior puncture, one should see a part of the capitulum of the humerus, when the elbow is strongly flexed; a part of the trochlea, usually only the lateral ridge; the head of the radius; a part of the olecranon, usually its lateral aspect but not its under surface; and a little of the joint space. The best position of the elbow seems to be strong flexion, with strong traction in the line of position of the limb, in an attempt to separate joint surfaces. Little separation is obtained usually. In extension all the structures are crowded together; they are somewhat separated in flexion. If the olecranon process is removed, the whole posterior part of the joint is seen, including the olecranon fossa. The anterior joint space, with the anterior joint parts, is not seen.

We were not able to distend the joint well by this posterior puncture in the unopened joint, since the needle could not be inserted far enough into the joint. Most of the lamp was in the soft subcutaneous tissues, and in one case, in attempting to force the needle in farther, it penetrated the cartilage and bone, so that the electric lamp, which did not fit well but projected above the groove in the trocar, was broken and lost, presumably in the joint.

7. *Other Joints*

We do not believe it yet advisable to recommend arthroscopy of the smaller joints, such as the great toe joint, temporomandibular joint, joints of the fingers, or the carpal or tarsal joints. Conditions are not satisfactory here for experimentation and it is not possible to reduce the lens system to a fineness compatible with such visualization. The possible exception is the great toe joint.

EFFECT OF DYES ON JOINT CARTILAGE, WITH ESPECIAL REFERENCE TO ARTHROSCOPY

The possibility of the use of dyes as an aid to arthroscopy came to mind at the suggestion of Dr. Schmorl, that it would be interesting to observe arthroscopically the formation of an experimental arthritis, through the use of colored substances injected into a joint. We decided to observe what general effect a colored substance, such as a dye, would have in a joint. We injected standard alcoholic eosin, diluted with water about one to ten, into the knee joint of an elderly man, dead of pneumonia. The joint was then examined to determine the effect of the dye. To our surprise, the eosin had selectively stained pink only well eroded areas of cartilage, especially a large eroded surface on the under surface of the patella. The menisci had stained slightly, and the eroded tibial condylar cartilage had stained well. The synovial membrane had stained in selected areas. We saw at once that this *selective staining of cartilage* could be of use in arthroscopy, in delimiting in color areas of necrosis or damage. We poured some of the eosin over the cartilage of this opened knee joint, and paradoxically, and to our greater surprise, all cartilage stained a deep pink. The selectivity was lost on opening the joint and exposing it to the air. It was determined then to test the action of eosin when injected into a healthy knee joint. We soon had the opportunity of doing this in a young patient dying of causes unassociated with joint pathology. The eosin, so injected into a closed knee joint, did *not* stain the normal cartilage. There was only a slight synovial staining, and the cartilage appeared its normal glistening white, absolutely unstained. Pouring eosin over the cartilage of the opened joint stained all the cartilage a deep pink,—again a paradoxical phenomenon. This was then a further confirmation of the selectivity of eosin for diseased cartilage. The same results were obtained using the standard laboratory watery eosin.

We consulted Dr. Schmorl about these results and he told us that he did not know of any similar experience. In reviewing the literature so far, we find that little attention has been paid to the gross staining of cartilage, especially by intra-articular injection. Tillmanns, in 1876, injected Berlin blue into the knee joints of dogs, not through the usual puncture route, but through the bony canal of the amputated femur into the knee joint, after chiseling away the intervening bony plate. His purpose was to study the lymphatic system of the knee joint, with especial reference to resorption of the dye. He noted in his seven cases that the cartilage was stained diffusely blue, the stain being superficial and easily washed away. So far this is the only reference on the artificial staining of cartilage we can find. Schreiber, in analyzing the constituents of Belchier's madder, injected purpurin into the dorsal lymph sac of the frog, and found a selective vital staining of cartilage,—a purple-red hue. This observation is of first importance in that it indicates that cartilage can be selectively stained vitally.

The gross staining reactions of cartilage in disease are very interesting,—as in jaundice and hematoporphyrinaemia. We deal here with pigments circulating in blood. Whether this is the case in ochronosis, which stains cartilage black, is still mooted. In jaundice, it is affirmed in text-books of pathology that cartilage is not stained *intra vitam*. We have had several occasions to verify this. It should be remembered that Schmorl has shown that degenerated cartilage of intervertebral discs does take up the icteric stain *intra vitam*. It is the custom in the Pathologic Institute in Dresden to remove the entire right femur for examination. On the right side, then, of all jaundice cases, the cartilage of the patella and of the tibial and femoral condyles, and even of the menisci, were stained green, the intensity of color varying with the length of exposure to air. On opening the left or untouched knee joint, or on examining it through the arthroscope, the cartilage and menisci were noted as definitely *not* stained. Pouring a drop of concentrated bile over the cartilage of the patella stains it a yellow green. A dilute solution of bile injected into the closed knee joint does not stain the cartilage.

It is not necessary to go into great detail concerning our experiments with various dyes and their action on cartilage. Our general purpose was to see if a dye would stain cartilage, when injected intra-articularly; whether it did so selectively; and whether there was any paradoxical reaction on pouring the dye on the open joint; and, finally, whether it was of value in arthroscopy. We have tried many of the usual laboratory dyes and noted their reaction. Whether the same reaction will occur in living cartilage, in a living patient, is still to be determined. We do know that the vital staining of living and dead tissues differ. Whether we can call intra-articular injection of dyes, for the purpose of producing an artificial staining of cartilage, vital staining is problematic; surely not so in the sense that Ehrlich meant it. For us, it is merely an academic question. The stain is superficial and, in most cases, can not be washed away, even with a strong stream of water. Both ground substance and cells stain; though, with neutral red, we have noted that the space between the capsule and the cell did not stain. Further experimental work is needed on animals to determine harmless dyes with selectivity for lesions, necessarily produced experimentally.

We have tried eosin, hematoxylin, gentian violet, methyl violet, neutral red, and many other dyes, and thus far it seems that only eosin and neutral red show the desired selectivity. Some dyes, such as methylene blue, stain too diffusely. It is important to find a blue or other dark-colored dye, since a reddish dye gives poor color contrast, especially in hyperaemic or inflamed joint conditions. We intend publishing our results in a separate paper.

What need concern us here and what has made this lengthy introduction necessary, is the value of dye staining of cartilage in arthroscopy. Stained areas show up definitely and clearly through the arthroscope. This has been our procedure, especially with eosin-stained joints. The

dye is injected into the previously water-distended joint (thus diluting the dye further) and then washed out at once repeatedly with water. The staining of cartilage and synovia is instantaneous. There is a tendency of the dye to settle to the bottom of the joint, over the menisci and tibial condyles in the knee joint. This will obscure vision, but with repeated washing or continuous irrigation of the joint, plus a pumping action of the joint, the return flow will come back clear.

The joint can now be examined through the arthroscope. The joint space in eosin-filled joints appears a dark fluorescent green, while the stained areas, as those on the patella and condyles, are pink. If we look at eroded areas in unstained joints, we find it difficult to distinguish them; when stained, they are clearly visible. In places, the synovia and its villi are stained a delicate pink. The menisci, if somewhat degenerated, stain also. In a joint injected with methylene blue by the above technique, the joint space is a peculiar blue brown in color and the synovia and cartilage stained more or less diffusely, bluish to greenish blue. Definite metachromasia of cartilage and soft tissues can be seen, the color gamut being from blue green to red purple. In one case, the ligamentum mucosum stained metachromatically a reddish purple, the menisci were a delicate, light blue, and the tibial condyles also a reddish purple. The metachromatic phenomenon on the tibial surface disappeared soon after the joint was opened and exposed to the air. These changes were all seen very well through the arthroscope and verified on opening the joint.

It is important now to find a harmless dye with definite powers of selective staining. Since the staining of cartilage is relatively superficial, the action of the dye should not be prolonged.

INDICATIONS AND CONTRA-INDICATIONS OF ARTHROSCOPY

It is to be expected that arthroscopy will not be used indiscriminately or to satisfy curiosity. We believe that the most important indication for arthroscopy is that it be used for diagnosis in place of the exploratory operation. But, until arthroscopic pictures of disease are standardized, arthroscopy should first be done, and the findings verified, when necessary,

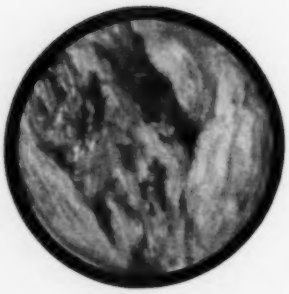
PLATE III

Knee joint of a limb amputated at mid-thigh because of a thrombosis of the vessels of the extremity. Age of patient not given, but presumably past middle life. Moderate arthritis present in knee joint. The closed joint was injected with a watery solution of methylene blue, examined through the arthroscope (Plate IV, *B*, *D* and *F*) and then opened to verify the findings. The opened knee joint is here depicted. Everything is stained more or less diffusely, with no particular tendency to selectivity. This is the usual finding with methylene blue. An erosion on one condyle shows no particular selectivity for the stain. Metachromasia of bone and soft tissues is noted. The cut ends of the ligamentum mucosum are seen, and both that and the crucial ligaments (the two crucial ligaments are more or less blended together without a sharp line of distinction, which is not uncommon in arthritis) are metachromatically stained. Through the arthroscope, it should be noted, the crucial ligaments were seen as only slightly stained. The superior tibial surface is colored bluish green in the illustration, though it was noted as reddish purple through the arthroscope. The color change took place quickly on exposure to air.

PLATE III
(See page 690)

A

B



C

D

E

F

PLATE IV

(See page 693)

PLATE IV

A, *C* and *E* are views of the knee joint of a man of seventy-four years, in which an extensive arthritis was present. The joint was injected with alcoholic eosin and examined through the arthroscope. Practically no normal cartilage was noted. *B*, *D* and *F* from the joint filled with methylene blue shown in Plate III. The findings here are those seen in the closed joint, when using the arthroscope.

A. Lateral puncture of knee, knee at 170 degrees. Part of the surface of the midpart of the external condyle, showing the eosin-stained cartilage. The joint space is a fluorescent green in color.

C. Knee in same position, same puncture. Joint space seen greenish, and into it project irregular strands of synovia, stained pink. The fat pad on the right is a part of the infrapatellar fat pad; the fat at seven o'clock that of the capsule.

E. Knee in full extension. At the right, the fat pads of the infrapatellar fat pad are seen projecting ovally into the joint, one behind the other. The joint space is a fluorescent green. Above, a small part of the patella is noticed, and below, and to the left, a part of the external condyle.

B. Lateral puncture of the knee, knee flexed to 90 degrees. One is seen looking down upon the intercondyloid fossa. The anterior crucial ligament is seen well, but its origin is not indicated. Part of the inner surface of the internal condyle seen. The anterior crucial ligament shows very little staining with the dye, though in the open joint it became metachromatically stained after exposure to the air. The bluish staining of the condyle is irregularly diffuse.

D. Knee in extension. The under surface of the patella is irregularly stained blue. The fat pads are also blue. The joint space is a peculiar brown, with a bluish tint.

F. Medial puncture of the knee, knee flexed to 90 degrees. The external condyle of the femur, as well as the external meniscus, is stained blue, while the superior surface of the tibia is metachromatically red purple.

by operation. If the findings arthroscopically are considered definite and decisive enough, it may not be necessary to operate. It is to be expected that, with time and the help of many workers in this interesting field, arthroscopic pictures of disease will become as well known as those of cystoscopy. There should be no hesitation in doing an arthroscopic examination, since it is simple, being a mere puncture in its ultimate essentials, and since it may avoid the more serious opening of the joint. The hole made by the trocar is heart-shaped, and less than four millimeters in diameter. Whether it is advisable to incise the skin to puncture the joint is a matter of preference.

Arthroscopy is also indicated in cases of joint disease, the diagnosis of which may be in question, and in which exploratory operation is not contemplated. It may be advisable to do an arthroscopic examination to make certain of the diagnosis and therefore to determine the treatment. Arthroscopy should also be done before reoperating on a joint for a possible relapse of an original condition. In this way may be determined, for instance, the posterior remaining fragment of a supposedly completely removed meniscus of a knee joint. Where biopsy is contemplated to secure synovial specimens, these specimens should be secured by an operative attachment to the arthroscope. Here one is enabled to inspect the joint and to remove the specimen without doing an open operation, especially in doubtful tuberculosis or tumor of a joint. Large bands of adhesion may also be cut by the operating arthroscope.

From the standpoint of experimental joint physiology and pathology, the use of the arthroscope provides an excellent means of observation *in natura* of the experimentally produced conditions. The formation of experimental arthritis, especially with the use of colored irritants; the formation of experimental loose bodies from detached cartilage or bone, etc., etc.; the duration of absorption of injected materials and their behaviour, especially when in granular form, can all be observed. The function of the crucial ligaments, still in dispute, can be observed to advantage.

Clinically speaking, with reference to individual disease groups, arthroscopy should be found invaluable in a whole host of diseases,—arthritis of joints, diseases of synovia or of the fat pads, intra-articular fractures, foreign bodies or free bodies, injuries to the menisci or crucial ligaments of the knee intra-articular tumors, tuberculosis and other granulomata, etc.

Therapeutically, ultra-violet light for internal irradiation of the joint cavity may be produced intra-articularly, and used in the treatment of joint diseases. This is still to be done for joint cavities and follows naturally from the work of Westmann.

Arthroscopy is contra-indicated where there is no definite indication for it. It should be used discriminately in collaboration with a good history and physical examination, and well taken roentgenograms. It is not intended that arthroscopy take the place of joint x-rays, nor should the latter be neglected.

SUMMARY

A new procedure for the examination of the larger joints has been described. Certain effects of dyes on cartilage have also been noted. We believe arthroscopy to be a key procedure in the study of joint physiology and pathology. The method as yet is still in its infancy and only the connected work of many men can establish its full value.

We wish to thank Dr. Harold Senior, Professor of Anatomy at the New York University Medical School, where the work was begun, and Geheimrat Med.-Rat., Prof. Dr. Schmorl, who at all times was most interested and cordial, and allowed us the free use of the material of his clinic. We also wish to thank Dr. José V. Santos for his help during the work in Dresden. The illustrations are by Fräulein Erfurth of Dresden.

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MYELOSCOPY
OR
THE DIRECT VISUALIZATION OF THE SPINAL CANAL AND ITS CONTENTS

BY MICHAEL S. BURMAN, M.D., NEW YORK, N. Y.

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We have examined eleven spines, removed intact from cadavera recently deceased, to determine whether it is possible to visualize the spinal canal and its contents. For this purpose, we used the instrument that we have employed in our arthroscopic work. The great fault of the instrument, which lent difficulty to our work, is that the point of the trocar plus the part of the trocar in which the lamp is lodged, is greater than the usual width of the canal. This meant, therefore, that some part of the lamp, or even of the front lens, might not be in the spinal canal. The average width of the spinal canal in the lumbar region is about three-eighths of an inch, but this varies. In cases where the canal was wider, we were able to see the spinal cord, the dura mater, and some of the nerve constituents of the cauda equina.

If puncture is made in the upper lumbar region, as between the twelfth dorsal and the first lumbar vertebrae, the dorsal surface of the spinal cord is seen, with blood vessels coursing on its surface. In one case, an area of hemorrhage was noted on the surface of the cord. It is difficult to see the conus medullaris, but we thought we saw it in one case. The filum terminale can not be seen. The gray sheen of the dura mater can be seen easily. The cauda equina, if puncture is made in the lower lumbar region, may be

seen, but not very clearly. We have seen what seemed to be individual nerve components of the cauda equina.

If sagittally divided spines are examined to determine the theoretical possibilities for vision, one can see the spinal cord, possibly the conus medullaris, and the upper part of the cauda equina. One can not individualize the nerve elements of the cauda equina distinctly. The gray of the dura mater can be seen well. Blood vessels coursing over the dorsum of the cord are easily seen and offer an index to the cord. The ventral surface of the cord is naturally out of the field of vision. The ligamenta denticulata can not be seen, nor the anterior or posterior nerve roots (it may be possible occasionally to see a posterior nerve root), nor their exit from the dura mater.

How far can one see up and down the canal? If a pin is laid horizontally across the canal from spinous process to opposite body, it can be seen clearly when the instrument is about one-fourth of an inch away from it. At a greater distance, less and less of the pin is seen, until at about a distance equal to three-fourths of the width of the lumbar vertebral body (about one inch or so), only a tiny point of the pin is seen. If the pin is stuck upright in the canal, it is seen in its entire length at a distance of about one-fourth of an inch; at one-half inch it is almost out of the field of vision. These findings show that the greatest field of vision in a single puncture field is about one-half inch, one-quarter inch upward and one-quarter inch downward.

The method is naturally theoretical in regions of the cord, since any puncture there transfixes the cord. But while the puncture can not be used on the living patient, yet it may be used at times in checking up a diagnosis *post mortem*, in a case in which the spine can not be removed. The method has its practical application only in the region of the cauda equina, where it may be useful in establishing the validity of diagnosis of diseases of the cauda equina, such as tumor or inflammation. It is impossible to introduce a visualizing system through the usual lumbar-puncture needle. The puncture hole made by the trocar which we used is a little less than four millimeters, which is much too large a hole to make in the dura mater. An instrument should be constructed which has a small gauge, and which is still large enough for the introduction of the visualizing system. It should also have a different type of trocar, in which the lamp would be contained in a more oblique groove in the trocar, both the groove and the point being made as small as possible.

In the routine lumbar puncture, it is seldom that a nerve of the cauda equina is struck, as manifested clinically by pain radiating down the leg. This should, therefore, not be a factor of consideration here.

The method may be called myeloscopy. For the most part, it is only of theoretical interest; but its greatest practical field of application lies in the examination of the region of the cauda equina. Since visualization is so poor there, for the present, further experimental study should be done with a more ideal instrument.

PROPHYLACTIC TREATMENT OF THE FREE CALLUS IN ARTICULAR TRAUMA OF CHILDREN

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The danger of trauma to the articulations in children resulting in the possibility of interference with the joint function is recognized in cases of necessary surgical interference with the joint after injury—such as fracture—as well as the need of care to avoid trauma to the joint and to the periosteal attachment, because of the danger of subsequent exuberant osteogenetic reaction, resulting from the operative trauma. This precaution is necessary in bloodless reduction as well as in the open operations, and consequently the two primary indications must not be forgotten in infantile traumatology;—first, the almost constant necessity of anaes-

FIG. 1

FIG. 2

FIG. 3

FIG. 4

thesia in the reduction of luxations or articular fractures in children; second, the avoidance of too much massage and violent mobilization in these lesions until after the osteogenetic tendency is passed.

It is necessary for three reasons to use particular care with the elbow joint: first, the joint is most frequently injured in children; second, this joint is most easily affected by osteogenetic exudates, preventing the ultimate free activity of the joint; and third, the difficulty of diagnosis even by x-ray of the simple periosteal or osteoligamentous lesions in the epiphyses, in which the ossification is not complete until adolescence. Also, at times, a disturbance of growth following these lesions of the diaphyseal cartilages is the cause of severe deformity. This should influence the pediatrician, as well as the general practitioner, not to give too favorable functional prognoses in articular traumata in children, even when the clinical and x-ray findings do not indicate severe lesions.

In the two cases reported, the conditions were disquieting to the surgeon, since it was feared that the open operation necessary to determine the condition of the osteo-articular and ligamentous attachments and their position might result in an injury to the integrity of the joint. It was, therefore, necessary to rely upon some means to limit the excess osteogenetic action, but the lack of cases reported in the literature on this subject prevented treatment being based on the experience of others. It was

FIG. 5

FIG. 6

believed that the x-ray was the only means of checking this process. In this the assistance of Dr. Sanchiz, Chief of the Roentgenologic Service at the Policlinic Institute, is acknowledged. Without actual experience on this subject and without data from the literature, but with knowledge of the effect of the x-ray on other bony processes, he could be confident of the success of this attempt.

In this x-ray treatment the technique was as follows:

Skin focal distance—53 centimeters.
Tension—200 kilovolts.
Filters—0.5 millimeters Cu and 1 millimeter Al.

The center of the lesion received a dose of 1050 international *r* units by two lateral fields—internal and external—and the skin received 720 *r*. These 720 *r* were administered in three sittings of twenty minutes each, on alternate days, over a period of two weeks.

CASE 1. D. F., female, eight years old. Family and personal history negative; five months previous had had a dislocation of right elbow; diagnosis at the time was a posterior dislocation without fracture (See Figures 1 and 2). The luxation was reduced and the arm immobilized for ten days, after which slight movements were begun, becoming more difficult each day. The mobility remained only two or three degrees, with supination and pronation abolished. Diagnosis when seen was marked functional limitation of the elbow (Figure 3). Operation was performed by anterolateral incision,—radial nerve found and displaced outward, removal of bony block attached to humerus and of exostosis at head of radius. Patient received the x-ray treatment described above. Post-operative course was favorable and early careful mobilization was used. Patient was discharged on tenth day. Angle of motion gradually increased; after six months there was within twenty degrees of complete extension and flexion of sixty-five degrees. Figure 4 shows the absence of any bony growth and only slight remains of the osteoma.

CASE 2. O. Q., female, eight years old. Family and previous history negative One month previously fell, causing luxation of the elbow which was not reduced. When first seen by the writer, the arm was in extension with only a few degrees of motion (Fig. 5). Diagnosis: unreduced posterior luxation of elbow. Bloodless reduction with anaesthesia was considered impossible. Treatment: operation, open method, posterior median incision; section of olecranon and opening of joint; ulnar nerve displaced inward; humeral exostosis removed; reduction of luxation; suture of olecranon by rustless wire; wound closed. Immobilization in right angle for ten days after which movement was begun. Four months later the elbow was free, lacking only thirty degrees of complete extension and flexion; there was full pronation and supination. Figure 6 shows the absence of osteogenetic reaction and disappearance of the shadow under the trochlea.

FIRST AID FOR FRACTURES

Methods and Equipment for the Treatment of All Fractures at the Site of Accident and on the Ambulance during Transportation to the Hospital

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Those of us who have had the thrilling experience of "riding ambulance" during our intern days will doubtless recall our rather meager first-aid treatment of fractures. We often did very little for our patient at the site of accident or en route to our hospital. We were anxious to get our patients to the hospital as rapidly as a speeding ambulance could carry them. Our methods of treatment were often inaccurate, due to lack of specific instructions and equipment.

While teaching the first-aid treatment of fractures to interns during the past few years, the writer has arrived at the following conclusions:

1. That the interns appreciate having specific equipment and knowing definite methods for treating any particular fracture.
2. That their work is carried out more accurately, quickly, and gently with this knowledge and equipment.
3. That when ambulance chauffeurs have been given specific instruction, they cooperate with and assist the interns.
4. That the patients are more comfortable.
5. That shock is lessened or prevented.
6. That our results in the treatment of fractures in general have been definitely improved since proper treatment has been instituted at the site of accident.

The author wishes, therefore, to outline the general instructions, the equipment, and the technique for the emergency treatment of fractures, as used by the interns of the Beekman St. Hospital, New York City.

GENERAL INSTRUCTIONS

1. Examine the injured part rapidly and gently and make a tentative diagnosis. If there is any question of a fracture, treat as a fracture until proven otherwise.

2. Apply tincture of iodin and sterile gauze dressings to compound fractures and lacerations. Do not attempt reduction of compound fractures by manipulation.

3. Do not attempt to reduce any fracture, except by apparatus traction, unless the displacement is so marked that a fragment of bone might pierce the skin if the fracture were not reduced immediately.

4. Treat for shock whether present or not in all major fractures,—by avoiding exposure, covering patient with blankets, and administering morphin (Magendie's solution) hypodermically. Uncomplicated fractures of the skull without extreme restlessness or severe pain should, however, have no morphin.

5. Apply emergency splints or apparatus.

6. Bring all cases that are possible fractures to the hospital.

EQUIPMENT

It is unnecessary to describe such standard ambulance equipment as stretchers, blankets, iodin, dressings, hypodermic syringe and morphin, etc., taking it for granted that such necessities are present in all ambulances, since they are used in many cases other than fractures. The following description is confined to the actual equipment used in the immobilization of all fractures. These materials are all contained in the so called "Ambulance fracture box", which is a wooden box measuring eighteen and one-half inches long, by seven inches wide, by five and three-eighths inches deep, with a hinged cover. Each ambulance at all times carries one of these boxes. It is the duty of the nurse in charge of the Emergency Room to replace any article that has been used, immediately after the ambulance returns; also to see that the boxes all contain the equipment as specified below.

CONTENTS OF AMBULANCE FRACTURE BOX

(See Figure 1.)

1. Nine heavy muslin hammocks, six inches by eighteen inches.
2. Nine metal clips (used commercially as paper clips and known as Acco Clamps, No. 325).
3. Two portions of cotton sheet wadding, six inches by six yards, folded to sixteen-inch lengths.
4. Eight muslin bandages, three by thirty-six inches.
5. Eight wooden tongue depressors.
6. Four strips of adhesive, one by sixteen inches.
7. Eight thicknesses of one-sixteenth inch basswood splint, over one of which the strips of adhesive (*6*) are placed.
8. Four strands of sixteen-ply clothes-line: two, two feet long; the other two, three feet long.
9. One-half roll absorbent cotton, Grade B.
10. One-half pound extra clothes-line, sixteen-ply.
11. Four three-inch gauze bandages.
12. Roll of two-inch adhesive.

In addition to the contents of the box, two special splints are used,—the Murray-Jones arm splint and the half-ring Thomas leg splint (See Figure 2).

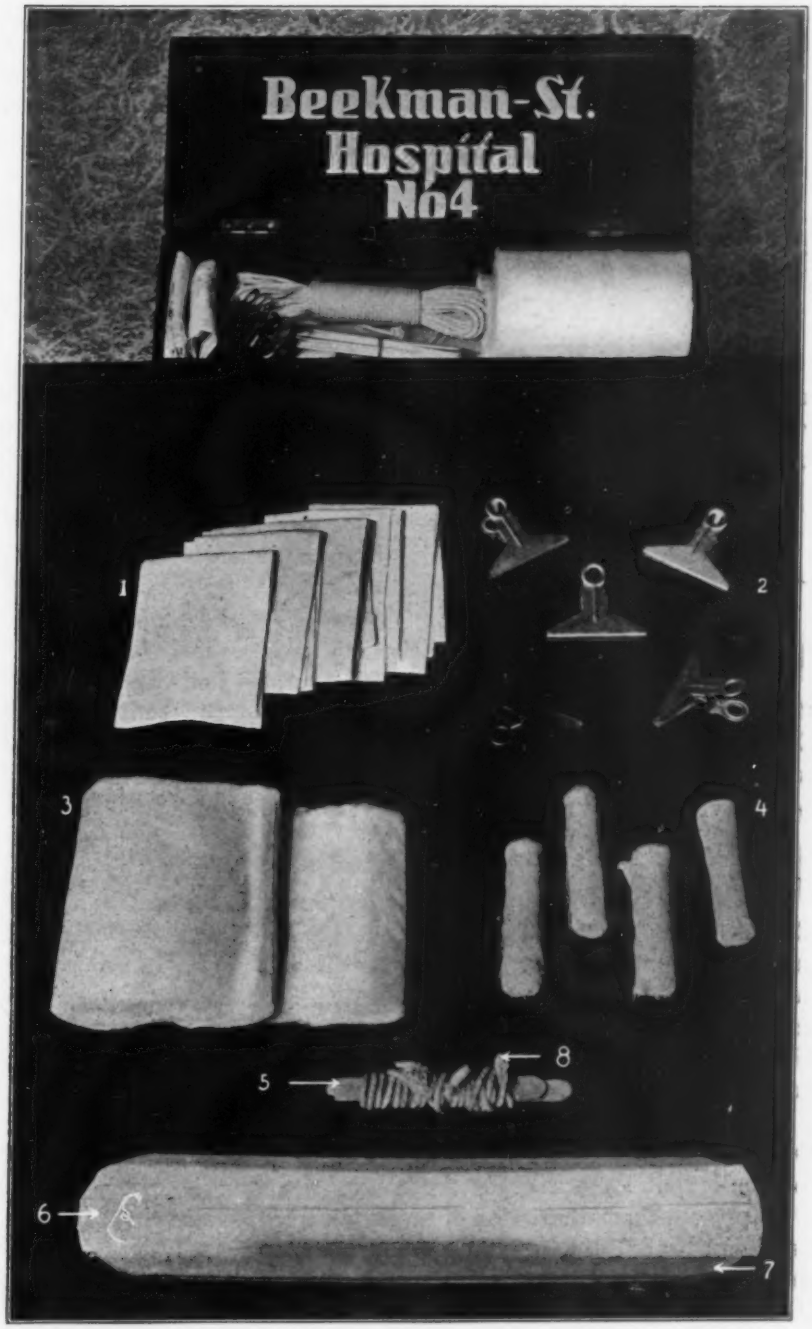

FIG. 1

Contents of Fracture Box. The materials shown in detail are only the specified equipment used in the application of the two traction splints. The additional equipment, used for the other splints, may be seen within the box.

Methods of Using the Equipment for Individual Fractures

SKULL, VERTEBRAE, PELVIS

No special equipment. Patient to be kept flat on back.

CLAVICLE, SCAPULA

Patient to be kept flat on back. Arm on injured side immobilized by a cravat sling, using gauze bandage (*11*).

RIBS, STERNUM

Patient to be kept flat on back. Chest should not be strapped unless there is evidence of marked displacement of fragments and then not unless there is opportunity to thoroughly shave the chest without undue exposure. The chest may then be strapped with adhesive (*12*).

ELBOW

Arm placed at right angles in front of the body and held in this position by sling of gauze bandage (*11*) around neck.

HANDS, FEET

Pad half a basswood splint (*7*) with cotton (*9*) and bandage (*11*) the cotton to the splint. With the remaining portion of the bandage, bind the splint securely to the anterior surface of the forearm, using the end of the bandage for a cravat sling about the neck to hold the forearm in front of the body. For the foot use a figure-of-eight bandage about foot and ankle.

PATELLA

Using two basswood splints (*7*), overlap them in the center so that the splint is double for a distance of about one-half the length of a splint. Fasten the splints together in the center with a strip of adhesive (*6*). Pad the center or double portion with cotton (*9*) and bandage (*11*) to the splint. Place the splint on the posterior aspect of the leg with the padded portion behind the knee and bind securely to the leg with the remaining portion of the same bandage.

Particular emphasis should be placed on the remaining two procedures,—first, that for the humerus; and second, that for the femur, tibia, and fibula; as in these fractures the interns' treatment is so very important in the prevention or alleviation of shock, the maintenance of the position of the fragments, and the beginning of the reduction of the fracture,—in other words, in obtaining better final results.

HUMERUS

(See Figures 3 and 4)

The following procedure is carried out: The ambulance arrives at the site of accident. The intern brings the ambulance fracture box and the

ambulance bag and, after determining the diagnosis, administers to the patient a hypodermic injection of one-fourth grain of morphin (Magendie's solution). The ambulance chauffeur brings the stretcher, blankets, and arm splint. While the intern is giving the hypodermic, the chauffeur places the patient on the stretcher, covers him with blankets, and starts traction on the arm. From this point the traction is not released. While the chauffeur is maintaining traction on the arm, the intern is placing four hammocks (*1*) on the Murray-Jones arm splint, fastening them with four clips (*2*). The chauffeur raises the arm while the intern places the splint over it so that ultimately the arm and forearm will rest upon the hammocks. The chauffeur continues to pull on the arm and also holds the ring of the splint firmly into the axilla. The intern places the folded cotton sheet wadding (*3*) around the wrist and ties a muslin bandage (*4*) around each side of the cotton sheet wadding with square knots. He extends the ends of these two bandages distally and ties them around the distal end of the splint with a square knot. Next, two tongue depressors (*5*) are placed in between these bandages between the hand and the end of the splint. These are wound to obtain traction as a Spanish windlass. The tongue depressors are fastened to the splint to prevent them from springing by a strip of adhesive (*6*). The chauffeur now releases his traction on the arm. The intern ties muslin bandages (*4*) above and below the elbow with square knots to further immobilize the extremity. The chauffeur holds the splinted extremity in suspension while the intern makes a loop with clothes-line (*8*—two feet) at the distal end of the splint. Into this loop he ties another strand of clothesline (*8*—three feet). The patient is now carried into the ambulance and the splinted extremity is suspended by tying the distal end of the second clothesline (*8*—three feet) to a metal ring on the inside roof of the ambulance. This procedure may be carried out gently and neatly in two and one-half to three minutes.

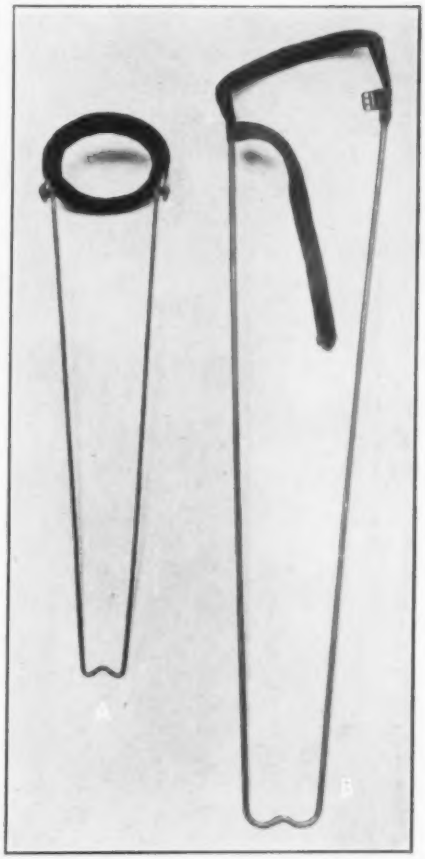

FIG. 2

(*A*) Murray-Jones arm splint and (*B*) half-ring Thomas leg splint.

FIG. 3

Emergency arm splint applied at site of accident.

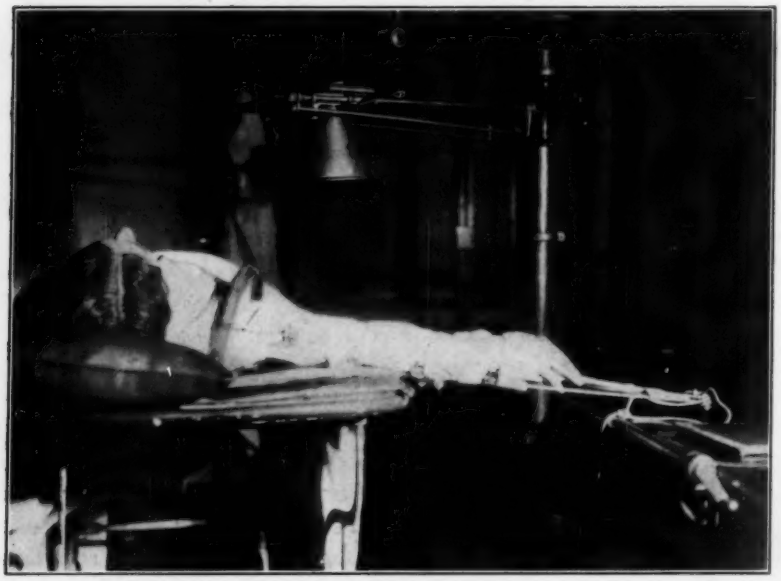

FIG. 4

Close-up of emergency arm splint applied (arm being x-rayed without release of traction).

FEMUR, TIBIA, FIBULA
(See Figures 5 and 6)

For fractures of any part of these three bones the same procedure is used, which is almost identical to that for the humerus. The intern and chauffeur work together. The hypodermic is given, the patient is placed on the stretcher, covered with blankets, and traction is started on the leg.

FIG. 5
Emergency leg splint applied at site of accident.

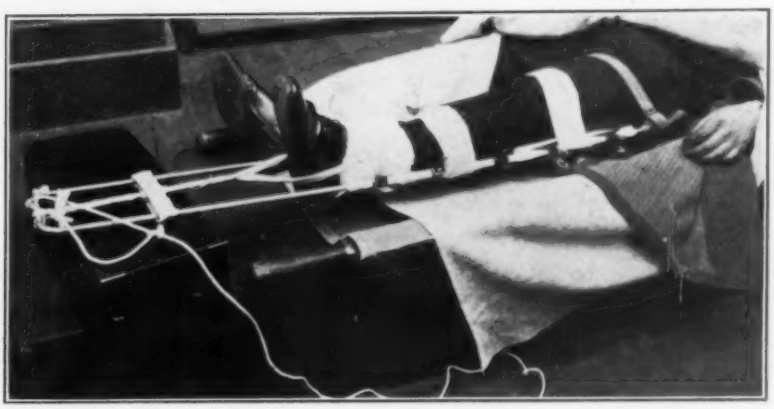

FIG. 6
Close-up of emergency leg splint.

The intern clips (*2*) five hammocks (*1*) to the half-ring Thomas leg splint and places the splint under the leg, buckling the splint strap around the front of the upper thigh. The ankle rests on the most distal hammock. The foot, with shoe left on, does not rest on a hammock. Sheet wadding (*3*) is tied around the ankle with muslin bandages (*4*), two tongue depressors (*5*) are wound between the bandages (*4*) and fastened with adhesive (*6*); two other muslin bandages (*4*) are tied above and below the knee. A loop of clothes-line (*8*—two feet) is tied to the distal end of the splint and a second strand (*8*—three feet) is tied into the loop, the distal end of the second strand (*8*—three feet) being tied to the ring on the inside roof of the ambulance, to suspend the extremity. The procedure for the lower extremity may be carried out in three and one-half to four minutes.

THE SEPARATE NEURAL ARCH*

BY THEODORE A. WILLIS, M.D., CLEVELAND, OHIO

When Kilian[5], about seventy-five years ago, applied the term "spondylolisthesis" to forward displacement of the vertebral column on the sacrum, the condition described was associated only with the pregnant female. It was soon recognized however in the male and, with the increase of industrial hazard and perfection of roentgenography, is now more often identified in the male than in the female, and in the latter sex as often follows injury as pregnancy.

From its earliest recognition the displacement has been attributed, by most writers, to a break in continuity of the bony neural arch, occurring between the superior and inferior articular processes of the last lumbar vertebra. This releases the centrum of the last lumbar vertebra with its superimposed column from its bony anchorage to the sacrum. Differences of opinion as to how such dissolution takes place are still rampant. Whether the bone defect is the cause or the result of local inflammatory changes; whether the separation is due to lack of fusion of anomalous centers of growth, to injury, or to defective ossification of the cartilaginous arch are still matters for discussion.

Neugebauer[7] ascribed the laminar defect to the presence of a synchondrosis, or lack of fusion, between two centers of ossification, "from which each lateral half arch is formed". His authority for the existence of such double centers has not been determined, but may have been the work of Rambaud and Renault[9] who in 1864 (ten years after Kilian) referred to the formation of the neural arch by the junction of lateral anterior and lateral posterior centers of ossification. They referred also to primitive and complimentary centers of the arch.

Mall[6], reviewing the work of Rambaud and Renault, found that their deductions were made from studies by ordinary dissection and drying on a glass slide of their embryologic material. Such a method he considered inexact and explanatory of some of their unconfirmed findings. Mall himself, working with embryos less than one hundred days old, using the Schultz clearing method and the x-ray, found no evidence of accessory centers in the neural arches. He says, "At no time were accessory ossification centers seen".

Bailey and Miller[1] mention but a single center of chondrification and ossification in each half arch, as do Prentiss and Arey[8]. Keith[3] says, "The lateral limbs of the cartilaginous bow meet behind in the neural canal in the fourth month, thus completing the neural arch. . . . One (center of ossification) appears in each limb of the neural arch (eighth week)". Again he mentions three centers of chondrification for each half vertebra, one for the neural arch, one for the costal process, and one for each half centrum.

*From the Anatomical Laboratory, Western Reserve University, Cleveland, Ohio.

On the other hand, Bardeen[2], though giving the usual occurrence as a single center, states that, "sometimes in the fifth (lumbar) and very rarely in some of the others, there are found two centers for the arch on each side; one for the radix, transverse process, and superior articular process; the other for the lamina, inferior articular process, and spine". Whether Bardeen actually found such centers in embryos, or made such deduction from the study of separations found in later life I have been unable to determine.

Bearing in mind these conflicting opinions the writer has reviewed certain of his earlier publications dealing with anomalies of the lumbosacral area[13], and the present purpose is a discussion of that anomaly previously referred to as "separate neural arch".

Among 1520 human vertebral columns studied in the Hamann Museum of Western Reserve Medical School, seventy-nine were found which showed this defect in one or both laminae of one of the lumbar vertebrae, usually the last. In the majority of these the lesion was between the superior and inferior articular processes, so that stability of the lumbosacral joints depended upon fibrous union between the bone components of the affected neural arch. As stated in earlier papers, several skeletons were found in which the adjacent surfaces of the last lumbar and first sacral segments showed beveling from continuous or repeated displacement of the one on the other. Similar deformation was not found in any instance of intact neural arch.

FIG. 1

Photograph of the last lumbar vertebra of cadaver No. 1493 showing fibrous tissue bridging bone defects of the neural arch at points *1*, *2* and *3*.

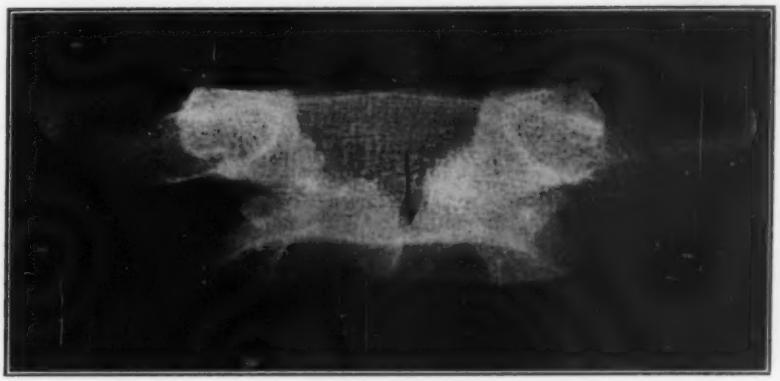

FIG. 2-A

X-ray of vertebra No. 1493 in anteroposterior view, showing splitting of spinous process only.

Since known bone pathology suggests no disease process that might produce a narrow transverse fissure of one or both laminae of a vertebra without other tissue involvement, inflammation as an etiological factor may be ignored. The possibilities then are injury and developmental anomaly. It is conceivable that either forced flexion or hyperextension of the lower back might fracture one or both laminae of a lumbar vertebra, and that mechanical factors consequent upon the upright posture would separate the fragments, preventing union. It may be conceded that under such circumstances no callus or other evidence of attempted repair would be found in the macerated vertebra. This theory, however, fails to account for the unilateral separations. Here we find a narrow transverse fissure across one side of the arch only. It is impossible to imagine more than a crack or green-stick fracture occurring in one side of a bone ring without damage to the opposite side. If such a fracture did occur it would be perfectly immobilized by the intact side of the arch. Yet in unilateral defects there is complete lack of callus, lipping, or other formation of new bone common to fractures. This appears ample ground upon which fracture as an etiological possibility may be discarded. In a number of bilateral separations also, the fragments were found too closely approximated to account for non-union of a fracture.

FIG. 2-B

Lateral view of No. 1493 showing suggestion of laminar defect.

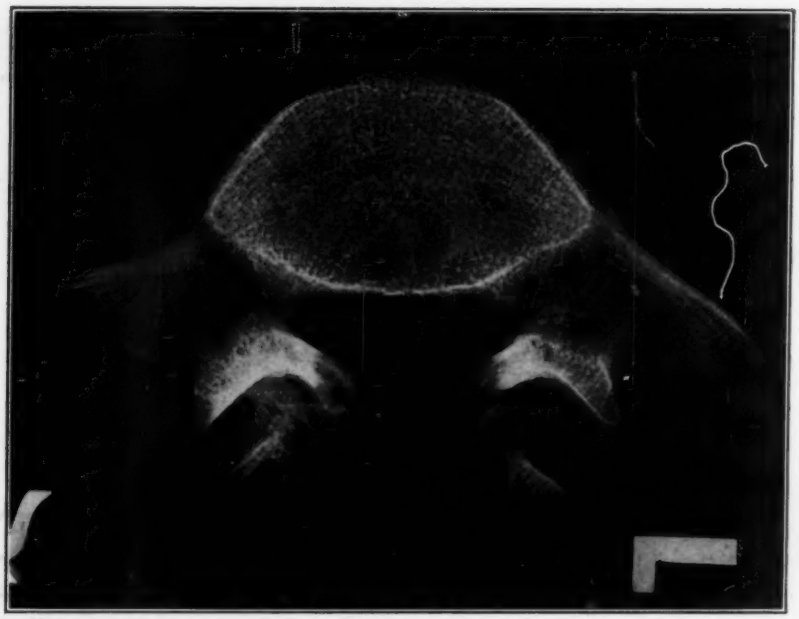

FIG. 2-C

Vertical view of No. 1493, showing left laminar and spinous process defect.

FIG. 2-D

Roentgenogram of vertebra No. 1493, in posterosuperior view, showing the bilateral defect, and bifid spinous process.

A study was made of the defect under discussion as found in the last lumbar segment of cadaver No. 1493. This was a colored male who died of pulmonary tuberculosis, aged thirty-one. The lesion was identified during special dissection and the last lumbar vertebra was carefully removed. The soft tissues were excised, leaving the periosteum. It was then determined that there was a defect in each lamina just distal to the superior articular process, and in addition the spinous process was bifid, having failed to fuse posteriorly. Thus the posterior half of the neural arch was formed of two symmetrical quadrants, each consisting of a lamina carrying an inferior articular process and half of a spinous process, the two bound tightly together posteriorly, and to the anterior half arch, by fibrous tissue. Practically no motion could be obtained between the separate components of the arch. Until the fibrous structures were removed the arch was normal to inspection (See Figure 1).

FIG 3-A

X-ray of patient showing forward displacement of fourth lumbar vertebra on the fifth, due to defect of neural arch of fourth. Note angle of inferior articular processes of this vertebra as compared to third and fifth.

FIG. 3-B

X-ray of patient showing forward displacement of fifth lumbar vertebra on the sacrum, due to separation of the laminae of the fifth lumbar. Note rounding off of the anterior lip of the sacrum and thinning of the intervertebral cartilage.

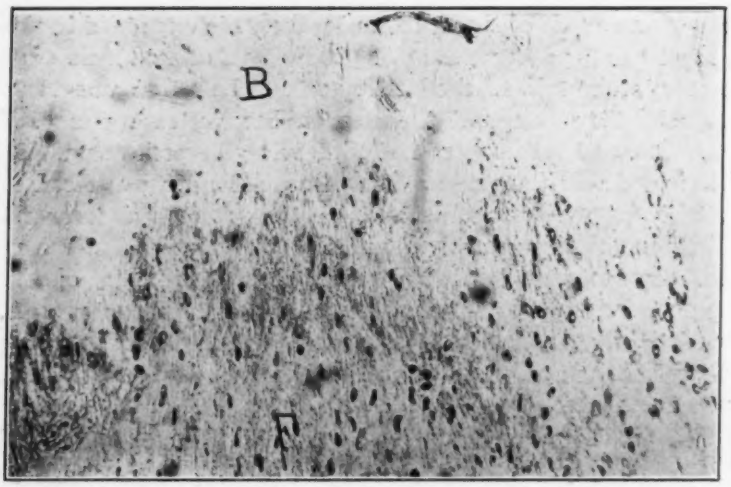

FIG. 4

Photomicrograph of a section across the laminar defect (*2*, Fig. 1) of vertebra No. 1493. Fibrous tissue stain, picrothionin, showing gradual transition from fibrous tissue *F* to bone *B*, quite unlike the usual demarcation between bone and periosteum.

X-rays made in anteroposterior view showed nothing but the spina bifida. Lateral views showed evidence of a defect, but posterosuperior or antero-inferior views were necessary to demonstrate the actual condition present (Figs. 2-A, 2-B, 2-C, and 2-D). These views are impractical in a living subject, hence x-ray diagnosis is very improbable until separation of the fragments is of considerable extent (Figs. 3-A and 3-B).

With a saw the defective area was removed from the left side of this vertebra and sectioned longitudinally to show the histological structure of the part. This consisted of coarse fibrous bands crossing between the fragments, anchored deeply in the bone at either end. These blend with the periosteum at the periphery of the fragments, but are much more generally and firmly anchored to the bone than is the periosteum. In some areas practically all of the fibers penetrate the bone, so that there is a transition from fibrous tissue to bone, rather than a sharp demarcation. (See photomicrograph, Figure 4).

Study of a number of vertebrae discloses that that part of a lamina immediately distal to the superior articular process, where the bone defect usually occurs, varies markedly in structure in different individuals. Cross section here may be of deep triangular shape or wide and flat. Moreover, this particular area is often notched laterally or even perforated for passage of vessels (Fig. 5). Each lumbar and iliolumbar artery, leaving the aorta, crosses a vertebral body laterally and sends a dorsal branch backward between adjacent transverse processes. This gives off a spinal element which divides into three smaller branches,—one to the spinal cord and its membranes, one to the posterior surface of the vertebral bodies, and the

FIG. 5

Photograph of a fifth lumbar vertebra showing perforation of both laminae immediately below the superior articular facets, and moderate notching on one side.

third to the neural arches and ligaments. It is this latter, winding around the lamina, which often notches or pierces the bone. The laminar branch may divide into ascending and descending branches before or after entering the bone. This was demonstrated in injected specimens. In certain instances of separate neural arch, the opposed ends of the laminar fragments are distinctly grooved by the vessel in its passage between them (Fig. 6). The arteries entered some laminae from the anterior and some from the posterior aspect, but in all specimens studied the point of entrance was as noted above, just distal to the superior articular facets.

It may be said in summarizing the statements of various embryologists that the membranous vertebral column is a continuous sheath of mesodermal tissue which begins to chondrify during the fifth or sixth week, first in the centrum about the notochord. The vertebral bow chondrifies to form the lateral portions of the neural arch, the extremities of which unite dorsally about the fourth month. The chondrified rudimentary spinous, transverse, and articular processes arise from this arch. Sclerotogenous tissue which does not chondrify remains to form the ligaments uniting the laminae of adjacent vertebrae. At the seventh or eight week a single center of ossification appears in each half of the neural arch near the

FIG. 6

Photograph of a fifth lumbar vertebra with separation of both laminae, showing grooving of the adjacent fragments at the site of defect.

base of the superior articular process, first in the cervical portion of the column. This extends forward to the centrum, with which it does not fuse until the fourth or fifth year, and backward to the transverse process, lamina, and spinous process. Osseous fusion of the spinous process begins at full term, extending upward from the lumbar region to reach the cervical at the fifteenth month. Interruption of this posterior fusion results in the well known spina bifida.

These opinions were confirmed in general in the foetal spines dissected in the course of this investigation. However, there seemed to be an intermediate stage of calcification of cartilage prior to actual osteogenesis, and into this calcified cartilage the real bone centers developed following the blood vessels. X-ray at this stage showed the structure opaque, but with no bone architecture of that portion surrounding the ossification centers. In strong transmitted light there appeared to be two separate areas of dense bone in each half arch, indefinitely connected by a narrow isthmus just distal to the developing superior articular process.

Serial microscopic sections of laminae at this stage, in both medial and transverse planes, show that these darker areas are centers of ossification

FIG. 7-A

Photomicrograph of foetal neural arch showing edge of ossification center with young bone trabeculae (*B*), transitional cartilage (*C*), and fibrous tissue (*F*). (See Fig. 7-B for localization).

made up of young bone trabeculae with transitional cartilage and bone cells, and large blood spaces (Fig.7-A). The proximal expansion develops the anterior part of the half arch, the distal one the lamina, inferior articular and spinous processes. The two centers are connected by a neck so small that it appears in only one-sixth of our serial sections, while the expansions are cut by nine-tenths of them. In those sections which do not cut the isthmus, there appear to be two separate centers of ossification in each half

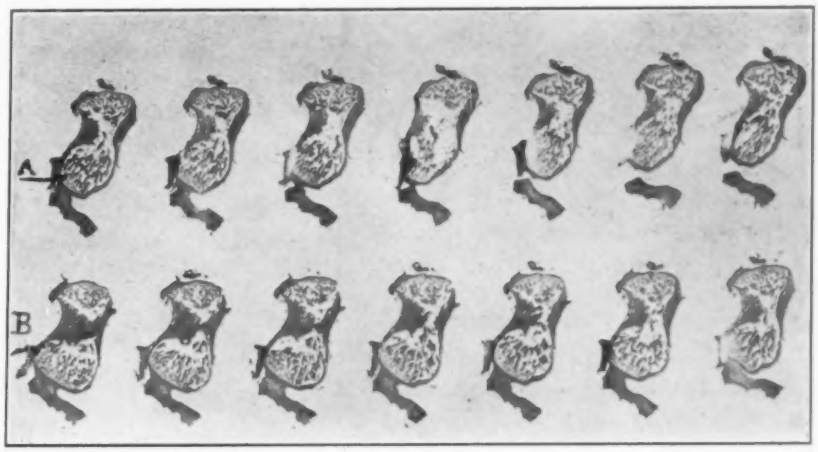

FIG. 7-B

Serial longitudinal sections from the center of an embryonic half neural arch. Note the terminal ossification centers. These communicated in only one-sixth of all the sections cut. In the others, such as *B*, there appeared to be two separate centers. *A* is the area appearing in higher magnification in Fig. 7-A.

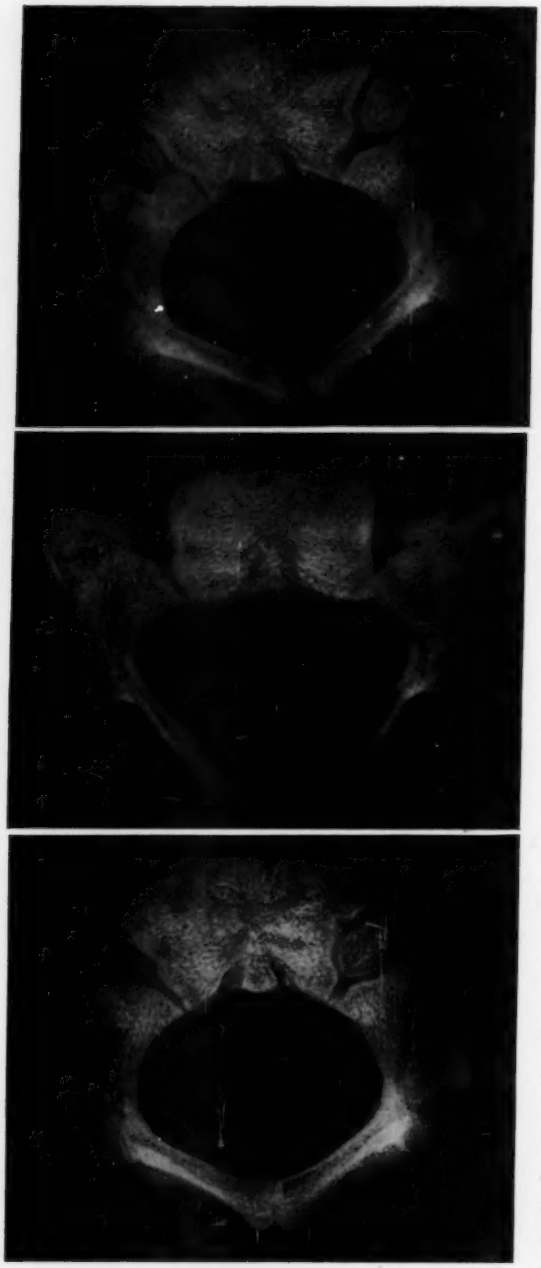

FIG. 8

Skiagrams of embryonic vertebrae (full term). The central figure shows a typical first sacral segment, with separate ossification centers for the lateral masses. The upper figure is a last lumbar vertebra showing bilateral anomalous centers. The third shows a unilateral anomalous center. The typical last lumbar segment shows no such centers.

arch. No doubt this is the explanation of such interpretation made from gross methods of dissection, and unconfirmed by others (Fig. 7-B). In none of the arches examined by serial section was the connecting isthmus absent, but the small number so treated by no means signifies that such a defect is improbable as an anomalous occurrence. Since true ossification follows invasion by blood vessels, it is certainly possible that, as the artery divides at this point either before or after entering the bone into ascending and descending branches, bone development may progress in a similar way and, fanning out in both directions, be defective centrally.

Variation from the usual arrangement and development of ossification centers frequently occurs in various parts of the skeleton. Some of the more common instances of this are the appearance of separate centers for the upper and outer quadrant of the patella, the tarsal scaphoid tubercle, and the postero-inferior border of the astragalus, which, owing to their frequent failure to fuse, in the adult are often misinterpreted as fractures. Examples occurring in the lumbar vertebrae are spina bifida occulta, absence of spinous processes, and the frequent variation of

the costal element and lateral mass of the first and last lumbar segments.

Anomalies and developmental defects of the lumbosacral juncture are so common that the term "normal" must be used here with caution. In earlier papers[13] this has been attributed to phylogenetic shortening of the vertebral column by progression of the pelvic complex upward on the lumbar vertebrae. During this process the last lumbar segment assumes the peculiarities of the first sacral, particularly in its lateral masses. In the retrogressive phase of this process the reverse is true, the first sacral presenting the characteristics of the last lumbar as it becomes freed from the sacral block. Since there are found all intermediary and partial changes between four and six lumbar segments, it is not surprising to find embryonic lumbar segments presenting ossification centers similar to those which in the first, second, and third sacral segments form the lateral masses which, according to Keith[4], correspond to pedicles and transverse processes, and, we may add, in some instances, superior articular processes of the modal lumbar vertebra. Such ossification centers, x-rays of which are here presented (Fig. 8), may develop the anterior portion of the neural arch and, following the common tendency of anomalous centers, fail to fuse anteriorly with the vertebral centrum, or posteriorly with the lamina, thus giving rise to that defect of the neural arch under discussion. (See Figure 9 for locations at which we have found these defects.)

The separate neural arch defect is common to all races. Turner and Tchirkin[12] reported a number of instances found in Russia, Shore[10] has recently described it as found in several native Bantu skeletons, Stewart is preparing a report on its occurrence in the Eskimo, and of course it has been discussed in European literature since Kilian's time.

The 1520 skeletons in the Hamann Museum from which our data are obtained are divided according to race and sex as follows: white males, fifty-eight per cent.; colored males, twenty-six per cent.; white females, nine per cent.; and colored females, seven per cent. Because of this disproportion, a comparison of the incidence of separate neural arch in race and sex is inexact, but there is apparently a greater frequency of occurrence in the white male, as of these six and six-tenths per cent. showed the anomaly, while three and five-tenths per cent. of the colored males, three and seven-tenths per cent. of white females, and but one and three-hundredths per cent. of the colored females were affected. The percentage of incidence in white males is approximately that found by Shore[11] in eighty-two Bantu skeletons (6.09 per cent.). Our

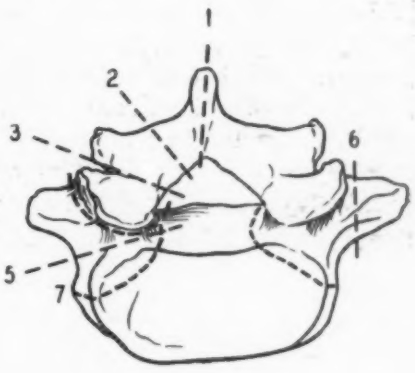

FIG. 9

Showing points at which separations of the laminar processes were found during this study. (Reprinted from *Am. J. Anat.* XXXII, 118, 1923).

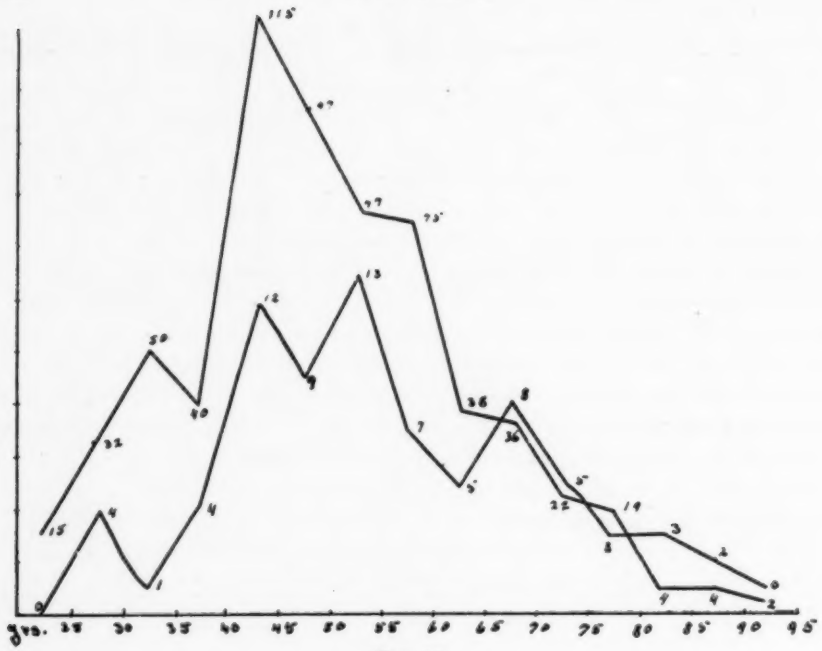

FIG. 10

The upper line shows the age incidence of the first 625 subjects examined. The lower shows the incidence of the seventy-nine defective neural arches in reference to age. To approximate the graphs the scale of the lower one has been multiplied by five.

colored subjects are considerably less affected than his, though the actual number at hand is greater.

The seventy-nine skeletons showing the defect, charted in five-year age periods (Fig. 10), show but negligible increase of incidence with age, as compared with the general age incidence of the first 625 subjects examined. The greater irregularity of the curve is due to the smaller number of individuals charted. The seventy-nine skeletons comprised five and nineteen-hundredths per cent. of the total number studied. In sixty-one of these the defect was bilateral, in sixteen the right lamina only was affected, and in two only the left. It was discovered once in the first lumbar segment, once in the third, four times in the fourth, once in both fourth and fifth, sixty-six times in the fifth, and six times in the sixth lumbar segment. Since but four per cent. of our skeletons have a sixth lumbar, this is an incidence in these of nearly twice that in the modal columns, suggesting relation of the defect to numerical variation.

CONCLUSIONS

The series of 1520 human skeletons at my disposal discloses separate neural arch in seventy-nine, or more than five per cent. In vertebral columns with twenty-five presacrals, the incidence is almost twice as great as in columns with the regular twenty-four, but the actual percentage in both series is an accident of the sampling rather than a criterion of the population at large.

Study of the defect, whether unilateral or bilateral, substantiates its essential origin in a skeletal anomaly and assigns a very minor rôle to trauma.

Embryologically the defect falls into the category of anomalous ossifications, of which there are many other examples scattered over the skeleton.

It is an anomaly peculiar to the lumbar region, and may be found in any lumbar vertebra and on either or both sides, but is usually confined to the last presacral. Thus spondylolisthesis may be a sign of the anomaly. Trauma plays a secondary rôle in this condition, finding the fibrous tissue a point of less resistance to strain than bone structure.

Separate neural arch in its origin resembles spina bifida, defective articular processes, and separate bony centers for transverse, mammillary and accessory processes which are peculiarly associated with the lumbar column; it is found more frequently when some other anomaly—such as a twenty-fifth presacral—is present. It is the ultimate result of imperfect ossification, whether this be caused by failure in the ossific process itself or by a defect of the pre-existing cartilage.

The writer wishes to express his indebtedness to Dr. T. Wingate Todd, Professor of Anatomy at Western Reserve University Medical School, who has very generously, over a course of years, placed the facilities of his Department at the writer's disposal and has permitted access to the most extensive collection of human skeletons in the nation,—perhaps anywhere. His counsel has been most valuable, and the members of his Staff most courteous and helpful.

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ARTHRODESIS ACROMIO-HUMERALIS OSTEOPLASTICA*

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Eight years ago I published a new method of arthrodesis of the shoulder joint in the Czecho Slovakian journal *Rozhledy v Chirurgii a Gynaekologii* (II, fasc. 1, 15, 1923), a favorable criticism of which appeared in the *Centralorgan für die Gesammte Chirurgie und ihre Grenzgebiete* (XX, 310, 1923).

Since it is recognized that the fusion of humerus and acromion, mechanically the most important and prominent point of the scapula, is often not sufficiently strong after the usual operation, and the humerus, which rises while the scapula is moving, is not reliably secure, I attempted to fix the humerus to the acromion more firmly. It is of course possible to secure the abduction of the arm sufficiently by the usual arthrodesis, but it is not possible to secure the forward elevation, which is a very important factor and which is not always attained after an arthrodesis of the shoulder (Wiedhopf).

The method described is as follows: an incision, beginning at the middle of the spine of the scapula, is carried to the acromioclavicular articulation and is then turned downward to a point about six centimeters under the acromion. With this incision both the skin and the atrophic deltoid are divided. The capsule of the joint is opened by a parallel incision, and dissected at the collum anatomicum, after which the head of the humerus is easily dislocated. The cartilage of the head of the humerus and that of the glenoid cavity is then removed and the subacromial bursa extirpated. The incision along the edge of the acromion is carried through the periosteum which is freed over an area of about one and five-tenths centimeters in breadth and five centimeters in length, and the lower flap of the periosteum is removed in the same way. Two parallel incisions are made by a saw in the caput humeri five-tenths to seventy-five hundredths centimeters in width, extending from behind forward and inward, and this portion of bone is elevated from its base by a small chisel, leaving a space of one and five-tenths centimeters in depth and five-tenths to seventy-five hundredths centimeters in width, into which the acromion, free from the periosteum, is inserted. The head of the humerus, free of the cartilage and properly prepared, is now in contact with the denuded glenoid surface. The wedging is generally so firm that it is possible to move the scapula upward and inward by the humerus, even during the operation. The periosteum is replaced and the soft parts sutured.

By this method it is possible to attach the humerus securely to the acromion, and, at the same time, to obtain the desired angle of abduction,

*From Prof. Yedlicka's Hospital for Crippled Children.

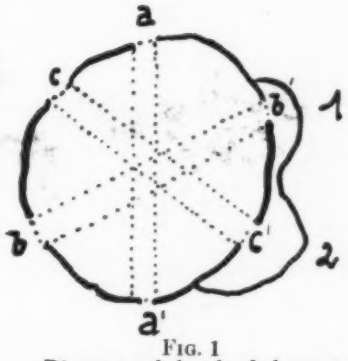

FIG. 1
Diagram of head of humerus seen from above.
1. Tuberositas minor.
2. Tuberositas major.

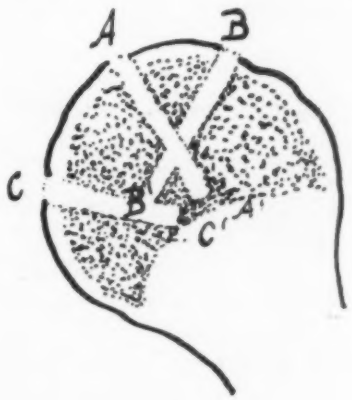

FIG. 2

rotation, and elevation, according to the direction of the desired incision in the head of the humerus. The incision with the saw is made in the direction a-a' (Fig. 1), the arm finds itself in negative rotation, with the incision in the direction b-b', the arm is rotated inward; in the direction c-c', the rotation is outward. With the incision in the direction A-A' (Fig. 2) there is abduction of about forty-five degrees, which seems the most desirable position, and which Dr. Gill recommends. The more the saw is inclined, the greater the abduction, but with the incisions inward C'-C, it is possible to obtain adduction. Fixation by means of wire is not used. During the postoperative period, the arm is fixed by plaster in abduction and elevation forward and the hand bound to the head by a soft cotton bandage.

It would appear that in the method described in the year 1923, and that of Dr. A. Bruce Gill published recently (*Journal of Bone and Joint Surgery* XIII, 287, April 1931), there is no substantial difference. The directions of the skin incision and incisions into the caput humeri show the main divergence. It is very satisfactory to know that another orthopaedic surgeon has employed the same method and has found it successful.

We agree with Dr. Gill that the most suitable age for the operation is from ten years upwards. However, we have operated in younger children with an extensive paralysis, which was resulting in serious dislocations of the shoulder, although in young children the thin and cartilaginous acromion makes the operation more difficult. The operation has been performed eight times in our hospital, three times on children younger than ten, the oldest eight years of age. In one case a fracture of the acromion occurred by sudden movement downward, after the removal of the plaster-of-Paris. After continued fixation for eight weeks, it was entirely firm. In one case there was a lack of fusion; in one case the patient died. This last case was that of a girl eight years old with marked paralysis and ex-

FIG. 3
Shows condition four weeks after operation.

treme dislocation. The child died four weeks after operation. The x-ray pictures of all these cases agree with those shown in the paper by Dr. Gill.

Both the osteoplastic arthrodesis published by Dr. Gill and that in our treatise eight years ago have proved successful in most cases and I believe that this operation is the simplest and at the same time the most precise method of arthrodesis of the shoulder joint. The difference between the operative method applied by Dr. Gill and that by myself is not of importance.

EXPERIMENTAL ARTHRITIS: THE CHANGES IN JOINTS PRODUCED BY CREATING DEFECTS IN THE ARTICULAR CARTILAGE*†

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The cause of chronic arthritis is unknown. Some of the theories which seek to explain this condition are based upon the fact that the pathological changes characteristic of hypertrophic arthritis can be produced in the joints of experimental animals by a number of different procedures. Among the more important of these is that of Axhausen[1], who believes that the pathological changes characteristic of the disease are due to the presence of dead cartilage within the joint. His theory is based upon some experiments performed by him in 1911 in which he applied tincture of iodin or ammonium hydroxid to the articular cartilage in the knee joints of a series of animals. The strong chemicals caused local necrosis of the cartilage and when the joints were examined several months later they were found to resemble those of chronic hypertrophic arthritis.

Shortly after this Wollenberg[2], in attempting to prove his vascular theory, produced degenerative and hypertrophic changes in the patella in dogs by passing silk ligatures through the tissues around this bone and thus shutting off its blood supply. He interpreted the results as being due to the local ischaemia and thus regarded the experiments as being proof of his vascular theory (Wollenberg[3]).

Axhausen and Pels[4] repeated Wollenberg's experiments and obtained practically identical results,—that is, hypertrophy and degeneration in the patella; but they believed that the hypertrophic changes were due to the cartilage necrosis which occurred, rather than to the ischaemia.

More recently, in order to eliminate the chemical factor in the production of the arthritis, Axhausen[5] has opened the joints of dogs and killed a portion of the cartilage with the cautery. The joints were then closed and, after a period of months, the changes characteristic of hypertrophic arthritis were found to have developed. Axhausen accepts these results as further proof that the presence of dead cartilage within the joint acts in some unknown manner, perhaps chemical, and causes the arthritis.

In order to check Axhausen's results and to determine whether or not function of the joint was a factor in the development of the pathological picture of arthritis deformans, Burckhardt[6] repeated the earlier experiments of Axhausen in a series of guinea-pigs by opening the joint and placing a drop of carbolic acid or iodin in the joint. In some of the animals

*From the Shriners' Hospital for Crippled Children and the Department of Surgery of Washington University, St. Louis, Missouri.

†Presented at the Annual Meeting of the American Orthopaedic Association, Chatham, Massachusetts, June 20, 1930.

he immobilized the joint completely either by suturing the leg under the skin of the shoulder or by placing small metal rings around the flexed elbows. In others he allowed the animals to use the injured joint normally. In the used joints the pathological changes characteristic of arthritis deformans developed in from three to five months, while in the joints which were immobilized the cartilage remained intact for a long time and then was gradually replaced by connective tissue and new cartilage which in some instances caused the joint to be filled with a cartilaginous connective tissue and tended to produce ankylosis with a picture resembling that of atrophic or infectious arthritis. He found that villi developed in used joints, while pannus developed in the immobilized joints; and concluded that arthritis deformans is a regeneration phenomenon which is due to cartilage injury and takes its anatomical characteristics from the mechanical stimulation incident to function of the involved joint.

In 1922 Fisher[7] reported that the removal of cartilage from a small area on the femur in the knee joint of rabbits under aseptic conditions resulted in proliferation of bone around the margin of the cartilage. He did not report his experiments in detail or rule out the factor of infection by cultures, but simply showed photographs of one such joint with some proliferation of the margin of the cartilage opposite the defect. He attributed the new growth to compensatory proliferation of the cartilage in the marginal zone.

Some years ago I repeated Axhausen's experiments by producing cartilage necrosis with various chemicals in a series of twenty-four guinea-pigs and obtained results similar to those reported by him. The results of these experiments were not published because they added nothing of importance to the original work of Axhausen except that, if larger amounts of iodin, alcohol, or carbolic acid were used, the pathological changes were considerably more marked and fibrous ankylosis of the joints occurred. The observation of Fisher suggested that cartilage necrosis might have relatively little to do with the picture and that the results were a reactive change, brought about by the removal of the cartilage, rather than by the presence of dead cartilage in the joint.

In this paper I wish to report the changes produced in the joints of rabbits by the aseptic removal of a portion of the cartilage.

MATERIAL AND METHODS

The animals used were all normal adult rabbits. Under ether anaesthesia the knee joint was opened by a mesial incision and the patella was displaced outward. With a small chisel a rectangular area on the front of the patellar surface of the femur, approximately three by six millimeters, was outlined and the articular cartilage was removed. A small amount of the underlying bone was removed with the cartilage. The wound was then closed in layers. In some instances the cartilage removed from the femur was left in the knee joint as a foreign body. Twenty rabbits were operated

upon, making forty knees. Three joints became infected and were discarded. The remaining joints were studied at intervals of from eight days to seven months after the operation.

GROSS APPEARANCE OF THE JOINTS

There was great variation among individual animals and between the two knees of the same animal in the changes which occurred after the operation. In some instances the defect in the cartilage was so thoroughly healed that its outline was barely distinguishable, and in the gross the floor appeared to be covered by normal cartilage. In other instances the operation was followed by a severe chronic, progressive arthritis which involved not only the femur, but also the tibia and patella.

In the joints which developed arthritic changes, the synovial membrane was definitely thickened and many folds or free bands were present in the lateral recesses on the sides of the condyles of the femur. There was also a variable amount of fibrosis and thickening of the subsynovial and capsular tissues and in some instances this periarticular fibrosis was quite marked.

The operative defect created in the patellar surface of the femur pursued a variable course. In some instances it appeared to be filled by tissue which resembled the surrounding cartilage and was so perfectly healed that its outline could be distinguished with difficulty. In other cases it remained as a slightly depressed area, the floor of which was covered by firm connective tissue and a few islets of cartilage. In a few instances the defect was markedly deepened and occasionally definitely enlarged and the depression was lined by tissue which resembled the normal synovial membrane.

The most interesting macroscopic changes were the hyperplastic phenomena which occurred in the lower end of the femur. These changes were not continuous with or even adjacent to the defect, but occurred in the non-traumatized portions of the lower end of the femur, and in many instances both the patella and the upper end of the tibia were also involved.

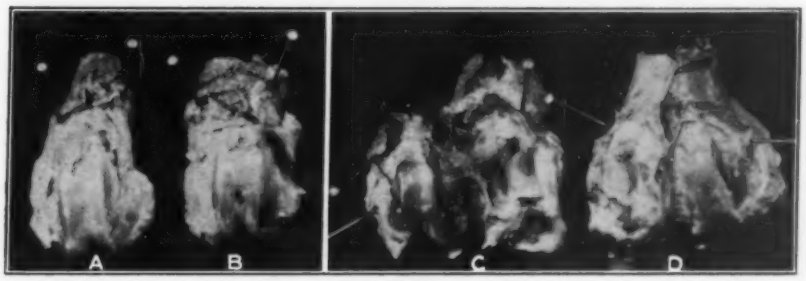

FIG. 1

Photographs of the knees of two rabbits removed five months after creating similar defects in the cartilage. *A*. Almost normal. *B*. Deepening of the defect and mild arthritis. *C* and *D*. Severe arthritis.

They were present to a variable degree in every joint when the animal was permitted to live more than a month after the operation, although in some instances the changes were so slight that they were discovered only on microscopic examination.

The most constant change was a broadening of the femur due to the production of new bone on the sides of the condyles. In some cases this new bone formation was so marked that the lower end of the femur was almost double the normal width. The next most frequent change was the formation of nodules or ridges of cartilage along the sides of the condyles of the femur close to the margin of the articular cartilage and opposite the defect. Some of these nodules contained bone and were quite large and might or might not be continuous with the articular cartilage. A third and fairly frequent change was the hypertrophy of the ridge along the anterior border of one or of both condyles.

In the joints in which the above changes were well marked in the femur, the patella was, as a rule, definitely broadened and there was definite hypertrophy (lipping) of the cartilage around the margin of the tibia and a variable amount of thickening of the upper portion of this bone.

Degenerative phenomena also occurred. The most common were softening, roughening, and even complete disappearance of the articular cartilage over the bearing surfaces of the condyles of the femur and tibia (far removed from the operative defect). Where the articular cartilage had disappeared, the exposed bone was eburnated and in these cases the free margins of the semilunar cartilages were roughened or fragmented. Another lesion which might be classed as degenerative was a punched-out depression in the fibrous tissue on the front of the femur above the articular cartilage. These depressed areas were present in only a few joints.

MICROSCOPIC CHANGES IN THE JOINTS

Microscopic changes will be considered under four headings: (1) synovial membrane; (2) the cut margin of the cartilage; (3) the defect; and (4) the non-injured portions of the bones.

1. *Synovial Membrane:* After the mild inflammatory reaction incident to the operation had cleared up, the synovial membrane tended to return to normal unless definite arthritic changes developed in the joints. When these changes occurred, there was in most instances a variable amount of hyperplasia of the synovial lining cells with the formation of villi and folds in the areas which were not subjected to tension or pressure. In the hyperplastic areas the subsynovial tissues showed increased vascularity and a variable amount of infiltration with small and medium-sized round cells. The round cells were usually scattered diffusely through the loose subsynovial tissue, but a few nodules were seen in some joints. These changes were roughly proportional to the amount of arthritis present in the joint.

In areas where the synovial membrane was subjected to pressure or tension, it became dense and fibrosed. In the joints which developed well

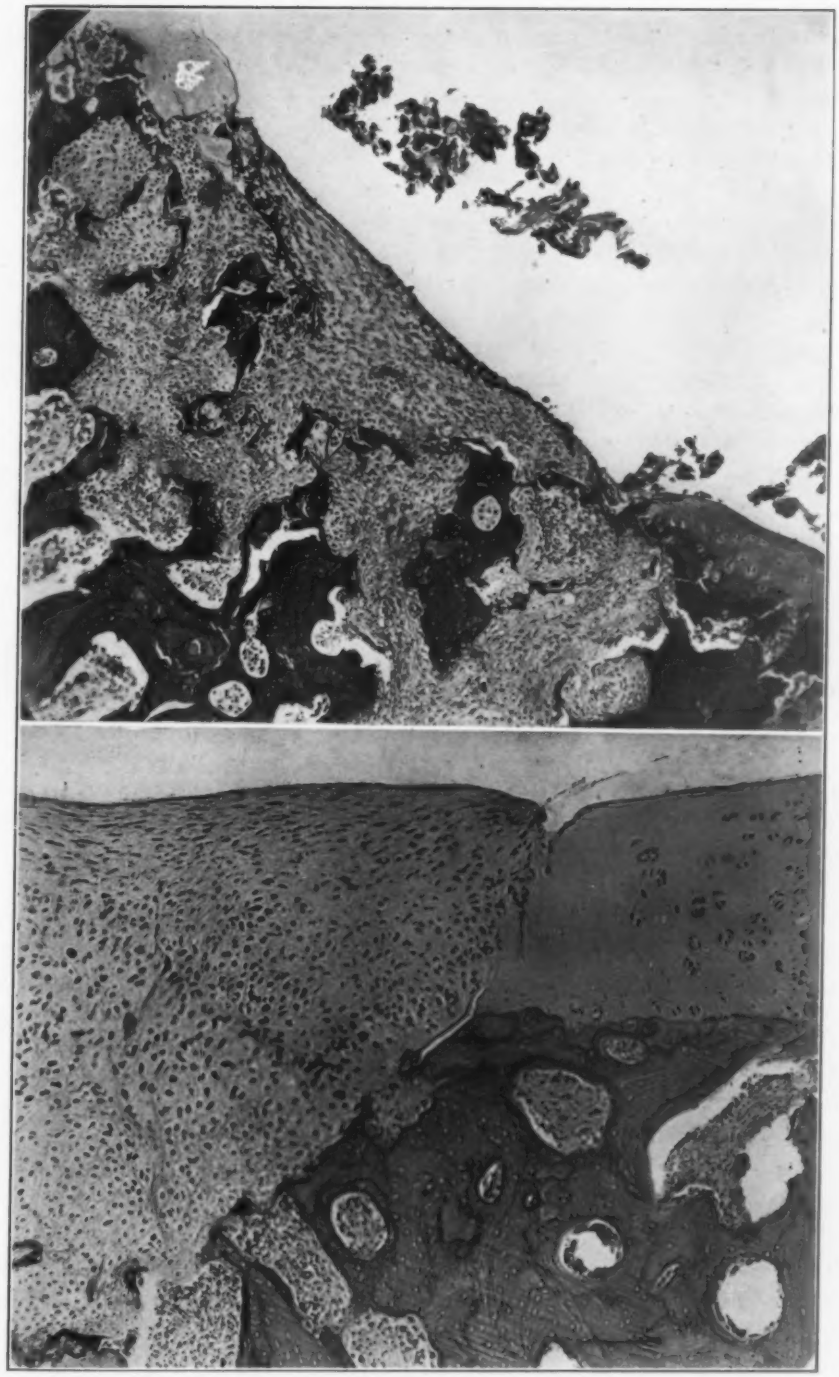

FIG. 2

Floor and margin of defect two months after the operation. Upper photograph shows defect filled with loose connective tissue which encloses many fragments of apparently dead bone. Lower photograph shows defect filled by atypical hyaline cartilage, the cells of which appear to be invading the apparently dead margin of the original articular cartilage on the right.

marked arthritis, there was a tendency to marked thickening and fibrosis of the subsynovial tissue and in three instances cartilage and a small amount of bone were formed around the sutures in the capsule.

2. *The Cut Margin of the Articular Cartilage:* In every instance the cells which were adjacent to the cut surface tended to die and disappear. In the joint examined ten days after the operation, there was an area of necrosis in the articular cartilage which was approximately equal in width to the depth of the cartilage. The more superficial lacunae were empty and the deeper cells appeared to be dead as their nuclei did not stain with hematoxylin. In the joint examined seventeen days after the injury there was some hyperplasia of the living cells near the dead margin, as was evidenced by the formation of cell nests and a tendency to enlargement of the isolated cells. In the later joints there were occasional evidences of slight proliferation of the living cells which lay adjacent to the dead cut margin, but in most instances these cells remained approximately normal in appearance and the dead margin persisted for many months practically unchanged, showing no tendency to disappear or to be replaced by living cartilage from the uninjured side. In other joints the zone of dead cartilage was gradually narrowed by an ingrowth of living cartilage from the callus which in these joints filled the defect.

3. *Changes in the Defect:* Changes in the defect may be divided into three types: (1) repair by cartilage; (2) repair by loose connective tissue with increase in the size of the defect; and (3) persistence of bare bone.

(1). Repair by Cartilage: This was the most common type of reaction found after the injury, and in one joint examined twenty-five days after the operation the floor of the defect was almost completely covered by young connective tissue, ten to twenty cells in thickness. This tissue resembled newly formed callus rather than granulation tissue and apparently sprang from the osteogenic cells lining the exposed marrow spaces in the underlying bone. This callus, if we may so term it, tended to dip down into the marrow spaces and was closely applied and seemed to be adherent to the apparently dead bone of the floor of the defect. This tissue contained two small fragments of bone (sequestra). In another joint examined thirty days after the injury the appearance was similar and in a sixty-day joint the defect was practically obliterated by a thick layer of cellular hyaline cartilage which appeared to have been produced by metaplasia of the callus described above. This avascular cartilage rested on the old dead bone and appeared to be continuous with the dead cartilage at the margins of the defect and its cells appeared to be invading the matrix of this dead cartilage. The underlying bone marrow was fibrosed and there was some evidence of eburnation of the bone in the floor of the defect.

In the later joints in which this type of repair occurred the cartilage resembled normal articular cartilage, except that the cells tended to be irregularly distributed through it and the surface was slightly fibrosed in character and the normal basal zone of columns of cells was not developed. However, in some instances a thin layer of bone was developed in the base

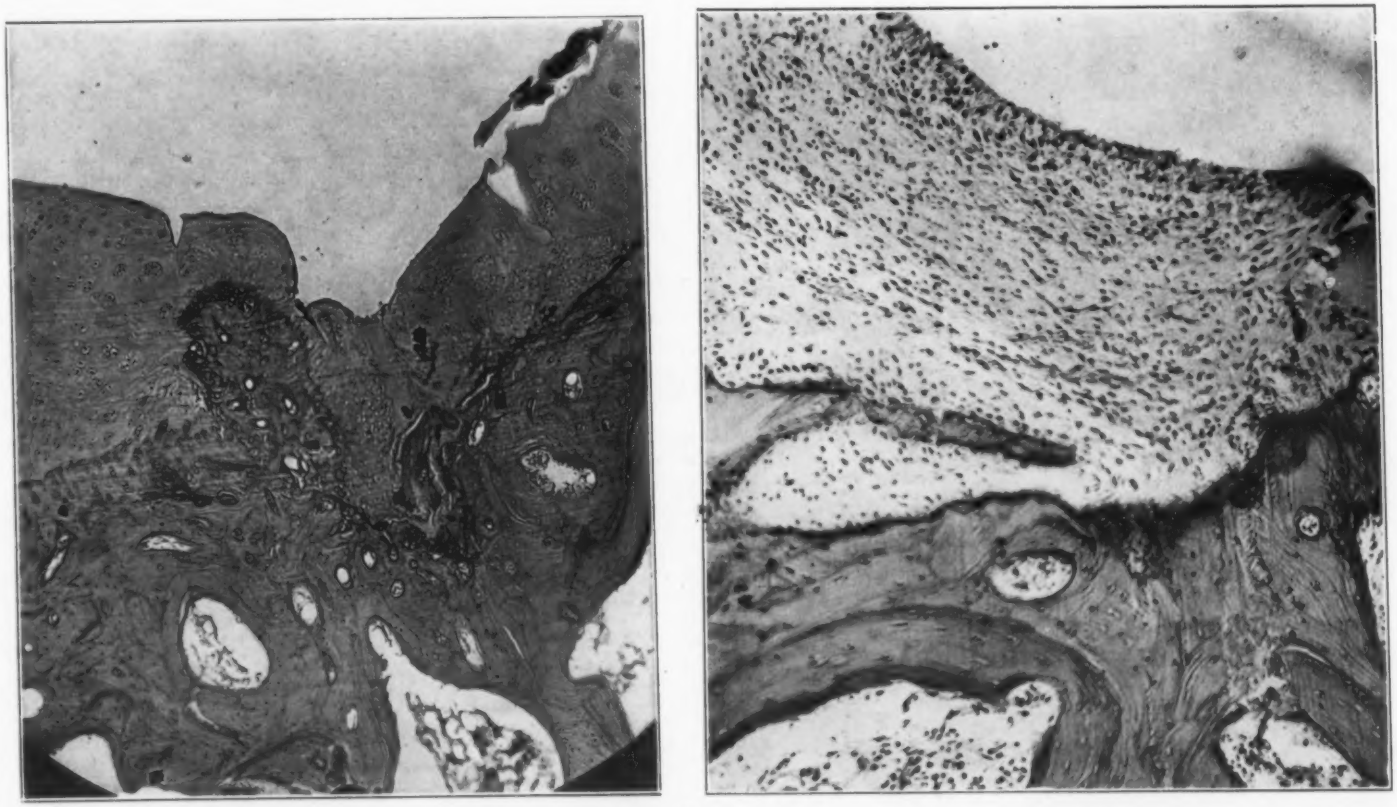

FIG. 3

Base and margin of defect six months after the operation. Photograph at left shows proliferation of bone at the margin of the defect and floor of defect covered by atypical hyaline cartilage. Photograph at right shows defect deepened and filled with loose connective tissue, the surface of which resembles the synovial membrane.

of the newly formed cartilage and this appeared to be continuous with the apparently necrotic bone which had been the floor of the original defect. In many of these joints there was a tendency to sclerosis of the underlying bone with fibrosis of the marrow adjacent to the defect. In all of the animals there was a clearly defined line of demarcation between the newly formed cartilage in the defect and the edge of the original articular cartilage at the margin of the defect, and in most cases the cut margin of the original cartilage remained dead and inactive.

(2). Repair of the Defect by Loose Connective Tissue: In a few joints the floor of the defect was covered over by a moderately vascular tissue which resembled the fibrosed bone marrow and the surface of this tissue was composed of a cellular layer which resembled the normal synovial membrane of the joint. In instances where this type of repair occurred the defect was always unusually deep and in some instances it was several times its original depth. This deepening of the defect was apparently due to progressive erosion of the underlying bone by osteoclasts and apparently all of the original floor of the defect had been removed and replaced by loose connective tissue.

(3). Incomplete Repair: In many instances the repair of the defect was incomplete. In the joint examined ten days after the operation the defect was filled with fibrin and the superficial layer of the exposed bone appeared to be dead, as many of the lacunae were empty and in others the nuclei of the cells did not stain with hematoxylin. The apparent death of the exposed bone was more extensive in the seventeen-day than in the ten-day joint and there was a definite difference between the mature bone cells and the young bone cells. The mature bone cells died down to a considerable depth in the exposed bone, but, in those areas where the bone appeared to be recently formed (stained violet with hematoxylin), only the cells close to the surface were dead.

There were many detached fragments of bone at the margins of the defect, where the chisel had been driven into the cancellous bone in order to outline the piece to be removed, and all of these fragments appeared to be dead. They were frequently enclosed in the connective tissue or cartilage which filled the defect. In some instances the bare exposed bone remained practically unchanged over a period of several months. In others the dead bone was incompletely covered by cartilage or callus-like tissue which grew out from some of the marrow spaces and tended to spread over the denuded surface like a pannus. Frequently this pannus was not adherent to the underlying bone. There was no evidence of sequestration of this layer of dead bone and no tendency for it to be absorbed by osteoclasts.

The exposed marrow spaces were usually filled with loose fibrous connective tissue which tended to seal off the marrow cavity from the joint and there was some fibrosis of the underlying marrow. In some cases irregular islets or buds of cartilage were formed at various points on the surface; in other instances islets of the deep layer of the original cartilage had been left in the defect and the surface of these appeared to be necrotic, while the deep

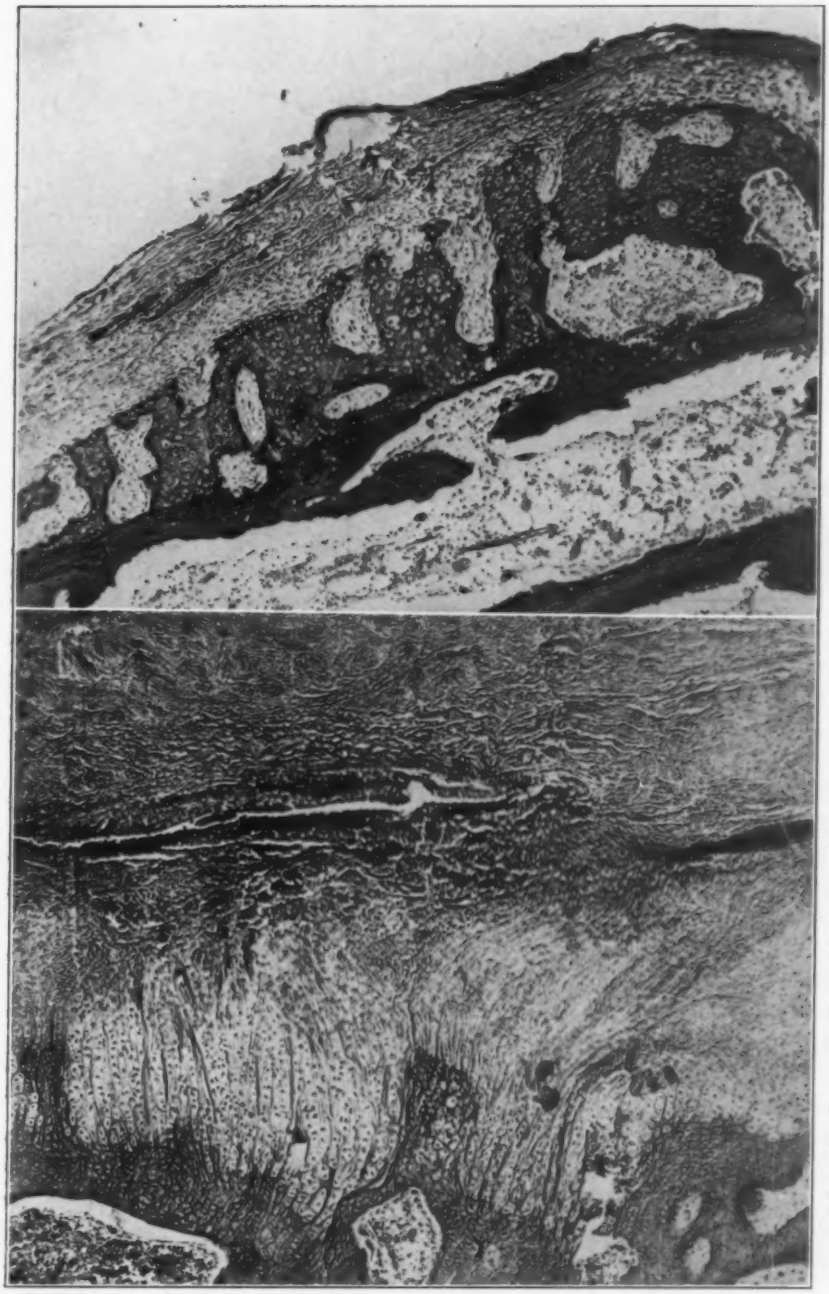

FIG. 4

Upper: Subperiosteal new bone on the side of the femur two months after the operation. Lower shows new bone and cartilage being formed on the margin of the tibia five months after the operation.

layers remained uninjured. There was no tendency for these islets of the original cartilage to spread out and cover the defect or even by proliferation to reform the superficial layers which had been removed.

4. *Changes in the Undamaged Bone*: The most important changes in these joints are those which occurred around the margins of the femur and in the tibia and patella. The most frequent change was the formation of new bone on either side of the femoral condyles. This new bone usually occurred as a thin subperiosteal layer of cancellous bone which appeared to have been formed directly, without the cartilaginous stage, and the trabeculae enclosed spaces which resembled the normal marrow spaces of the subcortical bone. However, in a few joints there were small areas along the side of the femur, in which the tissue was composed of cartilage cells mingled with small spicules of newly formed bone and resembled the callus formed during the repair of fractures. Consequently it is believed that in some instances the layer of subperiosteal bone is formed in cartilage. This layer was quite definite in the seventeen-day joint and in some of the later joints it was so extensive that the width of the femur was increased to such a degree that the bone was almost twice the normal width. As the layer of new bone increased in thickness and became mature, there was an osteoclastic resorption of the underlying original cortex and this, in the course of three or four months, had completely disappeared and the cancellous bone was continuous entirely across the femur. In these bones the new cortex was composed of the superficial layer of the newly formed bone.

In other joints definite nodules of hyaline cartilage were present. Most of these were located near the margin of the cartilage along the ridges of the condyles, but some of them were far down on the side of the femur near the posterior border and were completely detached from the original joint cartilage. Some of these nodules were very large and projected far out from the condyle of the femur. The surface zone of the large nodules was composed of dense fibrous tissue which merged into the underlying cartilage. In some of them there was a basal zone of bone, such as occurs in the typical osteochondroma, and in others there was an ossification of the center of the cartilaginous mass. In some joints these cartilaginous tumors alternated with the subperiosteal cancellous bone mentioned above. In other instances the cartilage predominated and all of the overgrowth contained some cartilage near its surface. In the joints in which marked arthritic changes developed in the femur, these changes were also present in the tibia and patella, and border osteophytes were produced by the formation of cartilaginous exostoses, and in the tibia there was also a variable amount of subperiosteal new bone formation which was identical with that described above in the femur.

In some of these markedly pathological joints there was also marked erosion of the bearing surfaces of the femur and of the tibia. This was in the nature of a necrosis and degeneration of the surface cartilage rather than of an invasion from beneath by connective tissue. In the partly separated cartilage the cells died and the cartilage fragmented and fibrillated

FIG. 5

Upper: Proliferation of cartilage and fibrosis along the side of the condyle of the femur two months after the operation. Lower: Large osteocartilaginous tumor on the side of the femur six months after the operation.

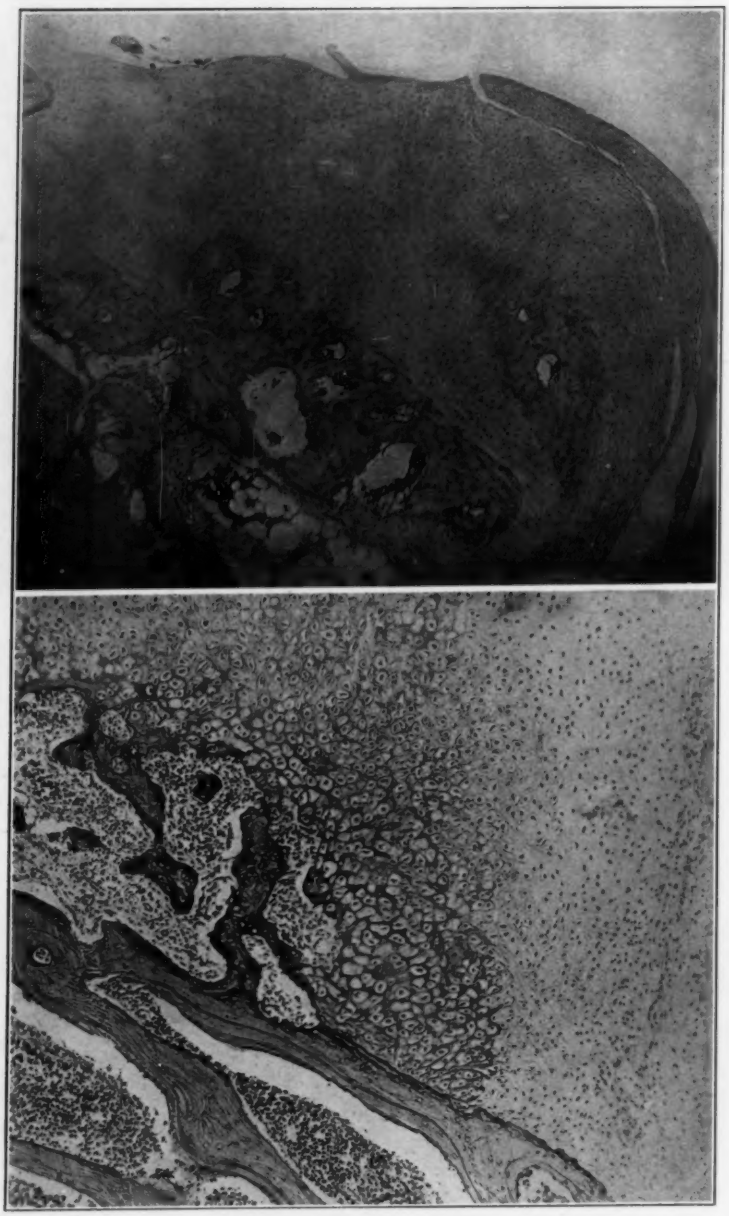

FIG. 6

Upper: Osteocartilaginous tumor of the margin of the condyle six months after the operation. In addition to the bone in the base of the tumor there is some bone in its interior. Lower: Base of osteocartilaginous exostosis on the side of the femur showing cancellous bone surrounded by cartilage which gradually merges into fibrous tissue six months after the operation.

FIG. 7

Upper: Bearing surface of the tibia showing degeneration and exfoliation of the cartilage with eburnation of the subchondral bone six months after the operation. Lower: Base of the defect five months after operation. At the left there is an islet of proliferating cartilage surrounded by bare and apparently dead bone. At the right is a small bit of the original cartilage which has not proliferated.

and was gradually sloughed off or ground off by joint motion. The superficial cells in the underlying bone died and the bone became eburnated just as occurs in chronic arthritis. In no instance was the eburnation of the bone ends connected in any way with the original defect and in no instance did it develop without other arthritic changes in the joint. In the cases in which it occurred, there was a variable amount of destruction of the semilunar cartilages.

DISCUSSION

The experiments reported in this paper prove that many of the changes which occur in hypertrophic arthritis can be produced experimentally in the joints of rabbits by simply creating a defect in the cartilage and that these changes are not dependent upon the presence of dead cartilage within the joint, unless one assumes that the small amount of cartilage necrosis around the borders of the defect is the cause of the arthritis; and this, of course, would be ridiculous. However, in order to determine whether or not the presence of dead cartilage within a joint produced arthritis, in a few instances I have removed cartilage from the articular surface of one knee, boiled it, and then inserted it into the cavity of the opposite knee. The dead cartilage became adherent to the fat pad and was gradually destroyed and no arthritis developed in the joint.

In studying these joints, I was not able to determine the nature of the stimulus to new bone formation; but, in going over a large number of sections, I was impressed by the fact that the bone marrow in the lower end of the femur in the joints which developed well marked arthritic changes appeared to be unusually vascular and that the blood vessels were larger as well as more numerous than normal. Whether this increased vascularity in the bone marrow is the result of the removal of the cartilage and the exposure of the underlying bone, or whether it is the result of the proliferative changes which occurred in the bone, I do not know.

It is interesting to note that the incision in the cartilage or bone which caused a cut surface to be exposed to the synovial fluid in the joint always resulted in the death of the cartilage or bone cells adjacent to this surface. Whether or not this death and disappearance of the cells in the cartilage or bone can be called a death of the tissue as a whole is questionable. The same thing occurs in fractures: the bone cells adjacent to the fractured surface die. Yet we have no evidence that in simple fractures the ends of the fragments are ever sequestrated or even absorbed after union occurs. Somewhat the same thing occurs in the surface of bone which is exposed in a joint by the removal of the articular cartilage. This bone may persist for a long time without being covered by new tissue and may become eburnated by the deposition of new bone in the adjacent marrow spaces; or it may become covered by cartilage or fibrous tissue, and in the animals of this series this tissue seemed to become adherent to the apparently dead bone which persisted *in situ* over a period of six or seven months.

The cause of the softening and wearing away of the cartilage on the bearing surfaces of the femur and tibia remains obscure, as these changes

occurred in joints in which there was not enough deformity to explain them by increased mechanical work; and careful study of the material has not revealed any satisfactory explanation of the phenomenon. I can only record its occurrence. Likewise, it is not possible to explain the hypertrophy of the margins of the tibia and patella and the laying down of new subperiosteal bone around the upper portion of the shaft of the tibia. I can only state that when marked proliferative changes had occurred in the femur, less marked changes of the same character were usually present in the other bones of the joint. In other words, damage to the femur seemed to affect all the bones of the joint, even though the traumatized areas of the femur did not come in contact with the tibia.

It has been noted that several types of reaction might result from the same type of injury. I have not been able to find any reason for a given type of change in these joints. The factor of infection has been ruled out by opening the joints under aseptic conditions and culturing small bits of synovial membrane. It appears that if two joints be subjected to practically identical operative procedures, one may return to a practically normal condition and the defect may be healed by cartilage which approaches the normal articular cartilage, and there may be no reaction in the bone or joint except the deposition of a very small amount of subperiosteal bone on the sides of the femur; while in the other joint a condition resembling severe hypertrophic arthritis may develop. In some cases animals developed a rather marked degree of arthritis in one knee, while the other knee which had been subjected to a practically identical operative procedure developed almost no arthritis at all. As a rule, however, both knees of the same animal showed about the same degree of arthritis. What the factor is which determines which process will occur has not been revealed by these experiments.

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THE DIAGNOSIS AND FREQUENCY OF TUBERCULOUS DISEASE OF THE KNEE*

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"Die Diagnose der primär-chronischen monoartikulären Gelenkerkrankungen ist eine der schwierigsten diagnostichen Aufgaben, die es gibt." (The diagnosis of the primary chronic mono-articular lesions of the joints is one of the most difficult diagnostic problems that exist.)

H. FRIEDRICH, *Münchener Medizinische Wochenschrift*, LXXV, 1153, 1928.

The late Norwegian surgeon, Hagbart Ström, in his well known work on tuberculosis of the knee[1]—based upon the University Hospital's material for the fourteen years from 1873 to 1887—writes as follows: "For the surgeon the clinical course and the macroscopic anatomical findings are sufficient to establish 'tuberculosis' as the diagnosis," wherefore he "has no hesitation in designating as tuberculous all the cases investigated." The cases were 200 in number. This is certainly clear and convincing language. It reflects in reality not only the view that prevailed forty years ago and had prevailed in the preceding two decades, or indeed ever since the relationship of the chronic diseases of the joints to tuberculosis began to be made clear (Billroth, v. Volkmann), but also the view that continued to be held during nearly a whole generation afterwards. For it is only within the last ten or fifteen years that we have arrived at a more correct diagnosis of the bone and joint lesions here under consideration.

To the Coast Hospital at Stavern, during the nineteen years I have been its superintendent (from September 1, 1911, to September 1, 1930), there have been admitted altogether 310 patients suffering from affections of the knee joint. Of these patients, 205 (66.1 per cent.) were found to be suffering from tuberculosis, while 105 (33.9 per cent.) were undoubtedly, or in all probability, *not* suffering from tuberculosis in the joint. All the more doubtful cases are accordingly reckoned as tuberculous. *Thus the proportion between tuberculous and non-tuberculous was as two to one.*

I have found in the literature three other statistical works dealing with the same subject. One of them is the work of Sven Johansson[2] from Gothenburg (1924), concerning 127 knee-joint patients, all children, treated from 1909 to 1923. He found that sixty-four, or fifty per cent., had not tuberculosis of the knee. The second work is Sorrel's[3], from Berck-sur-Mer (1925), embracing 140 knee-joint patients, all over fifteen years old. Of these 108 had tuberculosis of the knee (77.1 per cent.), whereas thirty-two (22.9 per cent.) had not. The third work is that of Burckhardt[4], from

*Read in condensed form at a meeting of the Norwegian Surgical Society in Oslo, November 1, 1930.

the Marburger Clinic (1927). *Of 223 knee-joint patients, admitted in the years from 1923 to 1926, it was found that thirty-nine (17.5 per cent.) had tuberculosis of the knee, while 188 (82.5 per cent.) had not.*

When dealing with a tuberculous affection of the knee, every one of our diagnostic methods may play us false in a given case. This applies both to the newest and most modern and to the old, well tried methods. Only some few of them—the value or lack of value of which I have observed—will here be mentioned.

The clinical picture presented by a tuberculosis of the knee is, generally speaking, either that of a fungus—tumor albus genus—or of a hydrops chronicus genus, or both of these.

The tumor albus genus was always regarded as tuberculosis by the doctors of olden days. But even as early as in his time, Franz König[5] had a faint idea of the fact that not every tumor albus genus was tuberculous. Indeed, in 1867, Lücke had introduced the clinical conception of tumor albus syphiliticus. Nowadays everyone who is dealing with such cases knows that other diseases, as well as tuberculosis and syphilis, can present the classical picture of a tumor albus genus.

A boy, aged about fifteen, was recently discharged from the Coast Hospital. He came from a poor family of many children and was admitted a year ago with the most typical tumor albus genus I have ever seen. Roentgen examination also revealed a great thickening of the capsule, with pronounced calcium atrophy. Sedimentation rate was forty-five millimeters per hour. Meanwhile, his reaction to tuberculin in doses of up to ten milligrams, given subcutaneously, was completely negative. His Wassermann reaction was also negative. Biopsy of the thickened capsule revealed "no sign of tuberculosis".* Five months after discharge, when the patient came in for changing of bandages and for inspection, the knee was distinctly worse, more swollen, with considerable tenderness and slight effusion. Tuberculin and Wassermann reactions were still negative. Roentgen examination revealed pronounced, almost hyaline atrophy, with extensive destruction of the cartilage in the joint. Resection was now performed and an intra-articular abscess with thick pus was found, besides pronounced destruction of cartilage. Biopsy showed no sign of tuberculosis either in the soft tissues or in the decalcified preparation.

In children, even in the earliest years of childhood (my youngest patient was one and a half years old), we may now and then meet with a swelling, often quite spherical, resembling tumor albus, in one or —more frequently— in both knees. The patient's entirely negative reaction to tuberculin precludes the possibility of tuberculosis, while the negative Wassermann reaction and the entire absence of any effect from antisyphilitic treatment rule out syphilis. At the present time, such a little patient, three and a half years old, is lying in the Coast Hospital, with tumor albus in the right knee

*All the microscopic investigations mentioned in this work were carried out at the Pathologico-Anatomical Institute of the University Hospital (Prof. Harbitz).

and hydrops genus (guinea-pig test negative) in the other knee. In such cases it is doubtless a question of incipient arthritis deformans.

The situation in case of the chronic hydrops genus is far more uncertain than in tumor albus. In some of these cases, where an injury has been sustained more or less recently, most probably there are present what Burckhardt calls "*traumatische Binnenstörungen*" (traumatic internal derangements); only an operative intervention can decide the matter.

Whereas Calot[6] maintains that, when the chronic hydrops genus does not yield to puncture treatment or compressive bandaging in the course of six or eight weeks, tuberculosis is almost always present, Friedrich[7,8] holds that the chronic lesions of the knee with thickening of the capsule and exudation, in the vast majority of cases, have nothing to do with tuberculosis, while Jüngling[9] has recently raised the question as to whether a hydrops genus is ever of tuberculous nature. Doubtless the truth lies somewhere between these two extremes, probably not midway between them, but considerably more towards the radical wing where the two last-named authors stand.

THE GUINEA-PIG TEST

The most convenient method of deciding the matter in case of a hydrops genus is, of course, inoculation from the puncture into guinea-pigs, still designated by eminent authors as our most sensitive test for tuberculosis (Kisch[10], Oehlecker[11], Wolfsohn, Friedrich[7,8]). This, however, does not hold good. Alan Smith[12] in fourteen cases of undoubted tuberculosis of the joints found the guinea-pig test positive in ten cases, negative in four. He concludes: "The only laboratory test that establishes the diagnosis is guinea-pig inoculation, and this is inconclusive when negative". Fritz König states that, in spite of a negative guinea-pig test, in some cases, he was able to ascertain that tuberculosis nevertheless was present in the diseased joint. Others,—for example Jüngling[9] and Wymer[13]—have gotten negative guinea-pig reactions in a number of cases of hydrops genus suspected of being tuberculous. The guinea-pig test is not in reality of as great value as supposed. We must first, however, distinguish between a purely symptomatic hydrops genus with a para-articular focus and the exudation due to inflammation in case of an intra-articular affection. The former is sterile. As regards the latter, *the guinea-pig test is decisive only when the result is undoubtedly positive, whereas even a repeatedly negative result does not preclude tuberculosis, or even a tuberculous synovitis.*

This situation Payr[14] explains by stating that the virus is confined within the synovial membrane, which acts as a filter and does not let the virus pass through until necrotic changes have arisen in the synovia, whereby this latter has become insufficient. Therefore the exudate is in most cases sterile. Thus it is said that the spirochaeta has never been detected in a syphilitic knee-joint exudate.

In reality this test fails far more frequently than many seem inclined to believe. That fact is clearly proved by the cases which I have examined.

In thirty-seven of my chronic cases, where fluid from the puncture was inoculated into guinea-pigs (by Dr. Thjötta) in the course of the last three and a half years, the result was positive in five cases, negative in thirty-two. In six of these thirty-two cases the microscopic examination showed that tuberculosis nevertheless existed. In two other cases the further course of the illness showed this to be true. In three of the cases examined microscopically the test had been carried out twice, both times with negative results, in one case even on inoculation with fluid removed during the actual operation. *Thus the guinea-pig test failed in twenty-five per cent. of the thirty-two negative cases.*

THE TUBERCULIN TEST

1. First, as regards the *positive* Pirquet reaction, it has an important significance only in the very first years of life,—up to the age of three or four years. In a child of this age with a tumor albus or hydrops genus, when any other infection can be ruled out, a positive Pirquet reaction will decide the diagnosis in favor of tuberculosis with a degree of probability bordering upon certainty. As years increase the positive cuti-reaction will lose in value as a diagnostic and will be entirely devoid of significance when the age limit is passed, at which fifty per cent. of the population gives a positive Pirquet reaction. This limit, which depends on many factors, seems from the investigations made in the last few years to have advanced to a considerably later time of life than before, and thereby the period in which a positive Pirquet reaction has diagnostic significance has also been prolonged (Scheel[15], Heimbeck[16], H. J. Ustevdt[17]).

2. In the next place, with respect to the *negative* Pirquet, we know that such a reaction—where a cachectic anergy or an anergy after certain diseases of infection can be barred out—does not preclude the existence of an active bone or joint tuberculosis.

3. The only convincing proofs are, on the one hand, *the absolutely negative result of all tuberculin tests up to ten milligrams* and, on the other hand, *a focal reaction that both objectively and subjectively is undoubtedly positive.* In surgical tuberculosis such a reaction is, however, as rare as it is capricious. Of this the investigations that have been carried out here in the Coast Hospital have long since convinced us.[18] Moreover it is not quite devoid of danger to try to produce a focal reaction in Pirquet-*positive* individuals by means of subcutaneous injections in rising doses. For these reasons, in the Coast Hospital, for several years past we have dispensed with the possible help this method might afford and confined ourselves to employing it only on Pirquet-*negative* patients, in order to be able—if the subcutaneous tests are also negative—to exclude with certainty the possibility of a tuberculous infection.

In the most recent years the focal reaction has been brought into further discredit through proof being furnished of the fact that *the reaction is not specific.* For, on the one hand, positive focal reaction has been produced by injection of non-specific substances,—such as typhus vaccine, milk, etc.

(Sorgo, Robert Schmidt[19] and others); while, on the other hand, positive focal reaction on injection of tuberculin has been obtained in disease foci of non-tuberculous nature (Mau, Schmidt, Erlacher[20]), or in tissue in which tuberculous changes could not be microscopically detected. Fourteen years ago I reported a case of chronic polyarthritis and polytendovaginitis in a nine-year-old boy, where undoubtedly positive focal reaction had been obtained with one milligram of tuberculin, but where on microscopic examination no sign could be discovered that tuberculosis existed or had existed.[21] Similar cases have since been reported by Mau.[22]

Alan Smith, in 1924, reported a case of sarcoma in the lower end of the femur, which showed a positive focal reaction to tuberculin, whereas in cases of undoubted joint tuberculosis he obtained no reaction. Altogether he believes that, if sufficiently large doses are used, we can obtain reaction also in non-tuberculous lesions.

Ernst Melzner[23] published two years ago from the Königsberger Clinic the results of tuberculin investigation in 161 patients where a diagnosis had been established. In 100 of these cases tuberculosis was present; in sixty-one there was no tuberculosis. Whereas among the tuberculous patients positive focal reaction was obtained in only twenty-two cases (22 per cent.), such reaction was obtained in twenty-eight of the *non*-tuberculous patients (45.8 per cent.). Hereby it is established that *an undoubtedly positive focal reaction is no certain proof of the presence of tuberculosis.*

In none of my cases of knee-joint tuberculosis was the diagnosis established by a positive focal reaction, while in a number of cases *the absolutely negative tuberculin reactions precluded the possibility of tuberculosis.* If it has not been made a rule in every doubtful case of gonitis to carry out the Wassermann test in the blood, or—what is still more reliable—in the fluid from an eventual puncture in the joint, then a negative tuberculin reaction is an absolute indication for the making of such a test.

ROENTGEN DIAGNOSIS

The value of roentgen diagnosis in bone and joint tuberculosis has long been overestimated. We are well aware that an entirely negative roentgen finding does not preclude the possibility of tuberculosis in a joint, and on the other hand a roentgen picture, of the kind we are accustomed to regard as characteristic for joint tuberculosis in the pronounced and advanced cases, affords no absolutely decisive proof of the presence of tuberculosis. Neither can we regard as absolutely decisive the periosteal deposits visible in the roentgenogram, which are always—and rightly—taken as indicative of syphilis or osteomyelitis and contra-indicative of tuberculosis. Observations made in recent years have shown that in undoubtedly tuberculous affections, apart from spinae ventosae, and especially in old fistulous cases with mixed infection, we may also meet with quite extensive periosteal deposits (Flesch-Thebesius[24], Fritz König). The formation of exostoses does not preclude the possibility of an arthritis deformans, secondary to a

still active tuberculosis, as we have many times been able to ascertain on operating.

In other words, *there exists no roentgen picture that is entirely typical of joint tuberculosis in any of its stages.* What applies in this respect to joint tuberculosis in general also holds good for tuberculosis of the knee.

The evenly diffused, calcium atrophy, which was at one time regarded as so characteristic of the tuberculous osteo-arthritis, is a phenomenon present in all joint affections that attack the synovia, and accordingly also present in the syphilitic lesion. However, in the syphilitic lesion it has always been and still is usual to take the absence of calcium atrophy in the roentgenogram as a differential diagnostic evidence against tuberculosis, which is entirely incorrect. The differential diagnosis here depends first of all upon the *degree* of calcium atrophy, and it is in the tuberculous lesions that we find the most marked degrees of evenly diffused, calcium atrophy, even to the hyaline atrophy in advanced destructive cases which by Kopelusch was regarded as typical of tuberculosis. But it is *not pathognomonic* for tuberculosis. In the above-mentioned case of tumor albus, non-tuberculous, the roentgen picture showed a high degree of calcium atrophy, almost hyaline, and the same was the case with a patient having xanthofibrosarcoma genus whom I wrote of a year ago and who had previously been treated elsewhere for tuberculosis[25].

On the other hand, a spotted calcium atrophy, even in very pronounced form, such as is frequently seen—although usually in a far higher degree—in the chronic "non-specific" synovitis, may also occur in undoubtedly tuberculous synovitis, as I was able to establish in one of my cases by microscopic examination of the synovia.

As regards the roentgen diagnosis otherwise, it must further be especially pointed out that in the years of childhood we find uneven contours of physiological nature, especially on the inner condyle of the femur (Ludloff[26]). The transition from the normal to the pathological is here very indefinitely marked. In one of my cases it was this finding that led me to think of a syphilitic affection, which also proved to be present.

The roentgen diagnosis is often rendered considerably more difficult by the fact that even extensive osseous changes in tuberculosis—such as foci or sequestra—may fail to appear on the roentgen plate, since they are just as poor in calcium as their surroundings; for which reason, in contrast to osteomyelitic foci and sequestra, they do not differentiate themselves from their environment. It is also a common experience with those who have to do with these matters for the operation to reveal destructive processes of which even the best roentgen pictures gave no warning. While Franz König found osseous changes in fifty per cent. of his operatively treated cases and Riedel as many as seventy per cent., Fritz König found in only nine out of ninety-eight cases operated upon (9 per cent.) an unmistakable focus on the roentgen picture[27].

But even if such a focus is revealed on the roentgen plate, yet this alone can tell us nothing certain as to the *nature* of the osseous changes,—

whether they are tuberculous, syphilitic, or osteomyelitic, or whether—as in one of my cases—osteitis fibrosa should be taken into consideration. As Fritz König remarks: "*We cannot practise pathological anatomy with the roentgen plate*".[28]

THE SEDIMENTATION RATE TEST

The limitation of this test lies in its non-specificity. An increased sedimentation rate tells us nothing more than that something is wrong somewhere or other in the organism. But it says nothing as to *where* the trouble is or of *what kind*. As far as surgical tuberculosis is concerned, we know that a normal sedimentation rate may be found even in an *active* tuberculous process. In general, however, the sedimentation rate in tuberculous gonitis, as in all chronic inflammations, is increased in a moderate or in a high degree. When we find an excessively high sedimentation rate in tuberculous gonitis, in most cases it denotes a complication, most frequently a pulmonary tuberculosis, a pleurisy, or a renal affection.

That an extremely high sedimentation rate may, however, also be due to a tuberculous affection of the knee joint is evidenced by those cases in which an exceedingly high sedimentation rate after amputation of the femur gradually reverts to the normal in the course of a relatively short time; this we have had an opportunity of observing on several ocasions.

If in a gonitis of uncertain nature a manifest tuberculosis or a complication of some other kind can be barred out, an excessively high sedimentation rate indicates an osteomyelitic process. This also accords with what Sven Johansson maintains: An extremely high sedimentation rate always ought to lead us to think of a septic process. In syphilis also, as in every inflammatory affection, an increased sedimentation rate is found, but in our experience considerably lower on the average than in tuberculosis. However, in syphilitic gonitis we may also find a very high rate of sedimentation; for instance, I have recently observed two cases with a sedimentation rate of forty-five and eighty-two millimeters per hour, respectively. The fact that, according as the cure progresses under specific treatment, the sedimentation rate gradually diminishes, until it at last becomes normal, proves that syphilis as such may alone be responsible for such a high sedimentation rate.

Summing up what has here been said on this subject, it is our experience that the sedimentation-rate test has not in any material degree enriched our diagnostic armamentarium in case of surgical tuberculosis. *But neither is it entirely without importance.* In a doubtful case it will, together with the other diagnostic evidence, be able to lay its small weight in the scales, for or against. The more pronounced the clinical symptoms are, the more will a low or normal sedimentation rate speak *against* tuberculosis, and so will likewise a high sedimentation rate with no very marked clinical symptoms, where complications can be excluded. An excessively high sedimentation rate will under the same circumstances speak *for* osteomyelitis and *against* tuberculosis.

THE COMPLEMENT-FIXATION TEST—(THE TUBERCULOSIS WASSERMANN REACTION)

When Wassermann seven years ago supplied us with this test, it was designated as specific in active tuberculosis. There are some who still assert that it is so; but we now know that such is not the case. Most of the investigations have been made in pulmonary tuberculosis, and in certain forms thereof—the exudative—positive reaction has been found in up to 100 per cent. of the cases. Out of seventy patients with pulmonary tuberculosis Thjötta and Edv. Gundersen found ninety-four and six-tenths per cent. positive.[29] Far less attention has been paid to the results in surgical tuberculosis, where, moreover, the investigations have been much fewer. The results here vary between thirteen and seven-tenths per cent. (Förtig[30]) and seventy and seven-tenths per cent. (Mozer and Fried[31]).

In our country Thjötta and Gundersen have investigated sixty-three cases of spondylitis from the Coast Hospital at Stavern. They here found a positive result in forty-four per cent. As regards tuberculosis of the knee joint in particular, I have found reported in the literature only one investigation—namely, that of the Italian, Ciaccia[32], who has investigated the reaction in fluid from puncture of the knee in eight cases of undoubted tuberculosis. He found the reaction positive (++) in six cases, negative (—) in two. "Slightly positive" reaction he does not reckon as positive. Thjötta has investigated the reaction in the blood of thirty-five knee-joint patients from among the chronic cases in the Coast Hospital.*

These I have divided into three groups:

I. Undoubtedly tuberculous gonitis.
II. Probably tuberculous gonitis.
III. Undoubtedly non-tuberculous gonitis.

In Group I there are seventeen cases; in thirteen of these the diagnosis was verified by the microscopic examination. In none of these thirteen cases was the tuberculosis Wassermann reaction *positive*, while it was undoubtedly *negative* in nine and "slightly positive" in four cases. In three of the remaining four cases the guinea-pig test in the puncture fluid was positive; in two of these three cases the complement-fixation test was negative; in the third slightly positive in the blood, but negative in the puncture fluid. In the fourth case, where the clinical findings made the diagnosis practically certain, the reaction was negative. Altogether, therefore, in seventeen certain cases of tuberculosis the complement-fixation test was negative in twelve cases, positive in none.

Group II comprises ten cases. In *one* of these the reaction was unmistakably positive (++), in two cases slightly positive, in the remaining seven negative.

In Group III there are eight cases. Of these *one* was certainly positive (++) (exfoliation of the meniscus), one was slightly positive, the remaining six negative.

*I wish here to convey to him my best thanks therefor.

Thus in Groups I and II we find the tuberculosis Wassermann reaction to be:

In one case positive (++) = 3.7 per cent.
In seven cases slightly positive = 25.9 per cent.
In nineteen cases negative = 70.4 per cent.
} 96.3 per cent.

If we now reckon, in accordance with Ciaccia, a "slightly positive" reaction as negative, the results in my cases will be negative in ninety-six and three-tenths per cent. The test should be far more reliable when carried out in puncture fluid from the joint. This was done in six of my cases, with the result that it was positive only in one case, slightly positive in four, negative in one. *In only one case was the reaction more strongly positive in the puncture fluid than in the blood,*—in one case it was slightly positive in the puncture fluid, negative in the blood.

It is of special interest to compare the result of the complement-fixation test in the puncture fluid with the guinea-pig test in the same. This has been done in all my six cases, with the result that the guinea-pig test in three cases was positive, in three negative. Of the three positive cases, the complement-fixation test was negative in two, "slightly positive" in one; while of the three negative guinea-pig tests, the complement-fixation test was positive in one, "slightly positive" in two cases. Thus in my cases a completely inverse relationship was found between the guinea-pig test and the complement-fixation test. In two of these six cases microscopic examination of the synovia was made. In one of these cases the result of the examination was negative as regards tuberculosis (here the clinical diagnosis was Poncet's disease), in the other case it was positive. In both cases the complement-fixation test was slightly positive.

On comparing the complement-fixation test with the Pirquet test it appears—to judge from my cases—that the Pirquet is a far more reliable test than the complement-fixation test, since the latter test, both in puncture fluid and in blood, failed where the Pirquet test was positive, whereas the converse was not true.

On summing up the results of my investigations it is found that the complement-fixation test, whether made in puncture fluid or in blood, is unreliable and even misleading. *A negative reaction in the puncture fluid is also entirely without diagnostic significance. On the other hand, a decidedly positive (++) reaction in the puncture fluid, or a more strongly positive reaction in the puncture fluid than in the blood, must be regarded as decisive, just as is the case with the Wassermann reaction in arthrolues.*

EXPLORATORY ARTHROTOMY

"Sicher unterlaufen ähnliche Fälle ohne Probeexzision oft als Tuberkulose und verbessern deren Heilungsstatistik". (It is certain that cases where no exploratory excision has been made often are included as tuberculosis and improve the statistics of cures.)

C. E. JANCKE, *Zentralblatt für Chirurgie*, LVI, 1038, 1929.

As to the justification of such an operation in doubtful cases, there should be no uncertainty when it is a question of adults. In the case of

children, however, we naturally shrink from making any intervention, including also this operation. But I think we ought to take a more liberal view of the matter, even when dealing with children, than we have hitherto done. Here in the Coast Hospital a negative result from an exploratory excision has rescued many patients from years of conservative treatment for tuberculosis and has also saved the patient from the unnecessary and depressing fear of the disease.

A number of authors from different countries,—such as, Burckhardt, Friedrich, Jancke, Fritz König, Oehlecker and others—, also maintain the justification of the exploratory arthrotomy in all doubtful cases. In America this operation has found warm supporters in Hibbs and Alan Smith. Among sixty-three cases of chronic joint affections, suspected of being tuberculosis, in which operative intervention had been made for therapeutic or diagnostic purposes with subsequent histologic examination, Alan Smith found that in twenty-five cases (39.7 per cent.) tuberculosis was *not* present. In the great majority of these joint lesions there seems to have been involvement of the knee.

In order to get an idea of the diagnostic value of the operation, I have divided my material into two groups. One group consists of the cases admitted in the period from September 1, 1911 to July 1, 1919,—that is to say, in very nearly the first eight years of my nineteen-year period. During this time the Coast Hospital, according to regulations, received only patients under fifteen years old, and it was only exceptionally that persons over that age were admitted. In the second period, however, from July 1, 1919 to September 1, 1930, adult patients were accepted also, and of late years in steadily increasing numbers. While in the first period patients over fifteen years formed only fourteen and seven-tenths per cent. of the total number admitted, in the second period they amounted to sixty per cent., being thus four times as many. Of the 109 knee-joint patients admitted in the first period, eighty-three (76.1 per cent.), were assumed to have tuberculosis of the knee, *while twenty-six (23.9 per cent.) were deemed non-tuberculous.* In the second period, on the contrary, the situation was as follows: Of 201 knee-joint patients, 122 had tuberculosis of the knee, (60.7 per cent.), while seventy-nine (39.3 per cent.), had not. The number of non-tuberculous cases was thus fifteen and four-tenths per cent. greater in the second period than in the first.

It may be suggested that the cause of this difference must be sought for in the fact that tuberculosis of the knee is more frequent in children than in adults, and that, therefore, the number of tuberculous gonites must obviously be greater where most of the patients are children than where adults are in the majority, and such an explanation cannot, of course, be entirely dismissed. Without entering further into the arguments for and against such an explanation, I must mention, however, that Sven Johansson, whose patients were all children, found fifty per cent. of non-tuberculous gonites, while Sorrel, in a group of patients consisting exclusively of

adults, found no more than twenty-two and nine-tenths per cent. non-tuberculous.

The main cause of the difference must, however, be sought for elsewhere and in the following circumstance:

Among 310 knee-joint patients treated during my nineteen years at the Coast Hospital, 131 were subjected to operation for therapeutic or diagnostic purposes. Of these operations fifteen were performed in the first period, 116 in the second. Thus we obtained an opportunity of verifying the diagnosis in one or the other direction by operative intervention eight times more often in the latter period than in the former. If the microscope had been employed with equal diligence in the earlier years, the number of non-tuberculous cases of gonitis would undoubtedly have proved to be still greater. For the experiences of these later years have shown that, if we make it a rule to use the microscope in every case operated upon, even in those where the macroscopic findings seem to be quite decisively in favor of tuberculosis, we now and then meet with cases where the macroscopic findings are confuted by the microscopic.

It is undoubtedly due to the numerous operative interventions in the latter period (of eleven years) that we find on the records of diagnosis for these years so many non-tuberculous cases as compared with those found in the first period. This is quite convincingly apparent if we examine the situation in the last four years,—from July 1, 1926, to June 30, 1930. In these years ninety-five knee-joint patients were admitted. Of these cases forty-eight (50.5 per cent.) proved to be of tuberculous nature, while forty-seven (49.5 per cent.) were not. Thus about fifty per cent. were non-tuberculous. Of the ninety-five patients twenty-six were children, sixty-nine adults. Of the twenty-six children sixteen (61.5 per cent.) had tuberculosis of the knee, and ten (38.5 per cent.) had not, while for the adults the figures were respectively thirty-two tuberculous (46.4 per cent.) and thirty-seven non-tuberculous (53.6 per cent.). Whereas the number of non-tuberculous cases of gonitis in children was thus four and six-tenths per cent. above the number of such cases in the whole nineteen-year period, in the case of adult patients it was twenty per cent. higher.

On sixty-one of these ninety-five patients operations were performed. Of these sixty-one patients five were children, fifty-six adults. The operation showed that none of these five children had tuberculous gonitis, but that this was the case in thirty-one of the fifty-six adults, while in twenty-five of the latter no tuberculosis of the knee was present.

All in all, therefore, among sixty-one operatively treated gonites thirty were found to be non-tuberculous, making forty-eight and four-tenths per cent.

While the diagnosis between tuberculous and non-tuberculous could accordingly be established in 100 per cent. of the operated cases, the situation as regards the thirty-four cases *not* treated operatively was quite different. Among these it was possible only in ten cases (29.4 per cent.) to establish a diagnosis with absolute certainty, and only in two of these

cases was the diagnosis in favor of tuberculosis. In one case the positive guinea-pig test decided the diagnosis, in the other the positive complement-fixation test in the puncture fluid, while at the same time it was "slightly positive" in the blood. In one of the remaining eight cases it was a question of osteochondritis dissecans. Three were cases of syphilis, while in four cases the entirely negative tuberculin reactions barred out tuberculosis. But in these four cases we came no farther than to the diagnosis "gonitis non-tuberculosa".

In the remaining twenty-four cases tuberculosis was present with a probability bordering upon certainty in fourteen cases (the absolutely decisive proof, however, could not be obtained), while in seven cases it was equally probable or certain that tuberculosis did not exist. The remaining three were cases of Poncet's disease. *All of these fourteen tuberculous patients were children, while among the seven non-tuberculous and the three with "tuberculous rheumatism" there was only one child.*

Without further demonstration it must be obvious that these four-year statistics, respecting a group of cases in which sixty-four per cent. of the cases were operated upon and the diagnosis thus established, are far more valuable than the nineteen-year statistics, where only forty-two and three-tenths per cent. of the cases were subjected to operation, not to speak of the eight-year statistics (1911–1919), where operation was performed only in thirteen and eight-tenths per cent. of the cases.

While, as already mentioned, the ratio between tuberculous and non-tuberculous affections of the knee in the whole period of nineteen years was two to one, *in the last four years it was one to one.* I am convinced that this latter proportion lies considerably nearer to the real state of affairs than the former.

Although there can thus be no doubt that an exploratory operation is fully justified, yet it should be regarded only as a last resort. Where a tumor albus is present, we can confine ourselves to making a small incision under local anæsthesia; but where it is a question of hydrops genus, or where a post-traumatic gonitis is supposed to exist, we must try to secure a full insight into the state of the joint and therefore must take into consideration the question of risking such a comparatively serious operation.

The fact that the microscopic diagnosis is not always easy or decisive should also be considered. Such a diagnosis as "chronic inflammation without specific character" may, as we know, cover a process of specific nature that has run its course. First and foremost the microscopic diagnosis in tuberculosis has to face the possibility of syphilis and here a definitely certain decision may be absolutely impossible. A typical example of this is the case of the following patient, who was recently discharged from the Coast Hospital. A girl, aged twenty-three, was admitted three months ago for tuberculosis genus, for which she had just been under treatment in one of our county hospitals, where, in spite of negative Pirquet and slightly positive Wassermann reaction, as well as a roentgen picture which showed, *inter*

alia, distinct periosteal deposits and therefore spoke definitely against tuberculosis, chiselling and scraping out of a para-articular focus had been performed, whereby there "was found under the considerably thickened periosteum a quantity of fluid pus". This pus was sterile. Microscopic examination of both the periosteal connective tissue and the decalcified preparation showed large caseous necroses surrounded by granulation tissue, in which were seen "in parts numerous tubercles". At the Coast Hospital it was ascertained that all tuberculin reactions up to ten milligrams were absolutely negative, while Wassermann reaction was ++. Antisyphilitic treatment resulted in a cure in the course of a few weeks. Renewed examination of the microscopic findings led to an alteration of the diagnosis. It was noted, *inter alia*, that "certain signs may speak for tuberculosis, but they are by no means pronounced and distinct. And there is nothing that speaks against, but a good deal that speaks in favor of, *syphilitic* tertiary granulation tissue".

Thus we see that this, our most accurate but at the same time most drastic means of diagnosis, may, like all others, not only fail but even be directly misleading.

"Gerade wenn man bis zum aussersten alle Mittel der Diagnostik erschöpft, bleibt eine Anzahl von Gelenken, deren Natur zweifelhaft bleibt—selbst bei Probeexzision. Aus diesem Grund halte ich Statistiken über Heilungsprozente bei Gelenkentuberkulose mit rein konservativer Behandlung für wertlos." (Even when we have completely exhausted all means of making a diagnosis, there remain a number of joint affections whose nature continues to be doubtful—even on exploratory excision. For this reason I regard as valueless the statistics respecting percentage of cures in joint tuberculosis with purely conservative treatment.)

FRITZ KÖNIG *Zentralblatt für Chirurgie*, LIV, 2466, 1927.

If we now inquire about the diagnoses in the 105 knee-joint affections in my statistics which were *not* of tuberculous nature, the answer will be as follows:

SUNDT 1930

Arthritis deformans	11		
Gonitis osteomyelitica	7		
Gonitis hæmophilica	3		
Gonitis luetica	21		
Gonalgia hysterica	2		
Chondrosarcoma gigantocellulare genus	1		
Xanthofibrosarcoma gigantocellulare genus	1		
Osteochondritis dissecans genus	3		
Chondropathia patellae	1		
Gonitis incertae causae	55	105	
Gonitis tuberculosa		205	310

I shall here confine myself to pointing out what is most remarkable in this survey,—namely, that in fifty-five cases it was not possible to make any certain diagnosis, that is to say, in fifty-two and four-tenths per cent. of all the non-tuberculous gonites and in seventeen and seven-tenths per cent. of the total number of cases. On comparing my statistics in this respect with

those of the three writers whom I have mentioned above,—namely, Sven Johansson, Sorrel, and Burckhardt, we find the following figures:

SVEN JOHANSSON 1924

Gonitis tuberculosa	63	
Gonitis septica	28	
Gonitis serosa	14	
Gonitis incertae causae	22	127

Out of 127 cases Sven Johansson enters twenty-two as "*gonitis incertae causae*", *i.e.*, thirty-four and four-tenths per cent. of all non-tuberculous gonites, or seventeen and three-tenths per cent. of all the cases. Meanwhile, in Johansson's statistics we find one group entered under the purely symptomatic diagnosis "*gonitis serosa*". In my statistics the cases of serous gonitis which were not of tuberculous or syphilitic nature, and where no other etiology could with certainty be established, are entered as "*gonitis incertae causae*". Therefore, if Johansson's and my statistics are to be compared, Johansson's two groups "*gonitis incertae causae*" and "*gonitis serosa*", between which Johansson himself says the boundary line is uncertain, must be combined. We then find that these two groups together formed fifty-six and two-tenths per cent. of all non-tuberculous gonites and twenty-eight and four-tenths per cent. of the total number of cases, thus giving considerably higher figures than my statistics.

SORREL 1925

I.	Sarcome du genou (tibia)	1	
II.	Arthrite ostéomyelitique	1	
III.	Arthrite gonococcique	1	
IV.	Arthrite syphilitique	10	
V.	Polyarthrite ankylosante, dont la nature n'a pu être définie	1	
VI.	Hydarthrose chronique	18	32
VII.	Tumeur blanche du genou		108
			140

Gonitis incertae causae (Groups V and VI, in all, 19 cases) forms fifty-nine and seven-tenths per cent. of the non-tuberculous cases and thirteen and six-tenths per cent. of all the cases.

In the eighteen cases of *hydarthrose genus* the presence of tuberculosis was precluded on account of negative guinea-pig test and negative culture experiment. All of these eighteen patients—all of whom had been admitted for tumor albus tuberculosus—were discharged as cured after some weeks or months. Sorrel therefore assumes that in the great majority of these cases it was a question of "*épiphysites de croissance*". Of the 108 recorded as tuberculous seventy-six were treated operatively. Nothing is

said, however, as to whether microscopic examination of the diseased tissue was also carried out. Of the ten patients recorded as having *arthrite syphilitique* the Wassermann reaction was positive in only one-third of the cases, but all of the patients were cured by anti-syphilitic treatment. Sorrel concludes by saying: "I have always these figures in my mind when I hear of miraculous cures of tumor albus of the knee and I cannot help thinking that very often it must be errors in diagnosis that permit of their being included".

BURCKHARDT 1927

I.	Sonstige Erkrankungen		78
II.	Traumatische Binnenstörungen operiert		47
III.	Tuberkulosen		40 (39)
IV.	Sichere oder wahrscheinlich Nichttuberkulosen:		
	a. wahrscheinlich traumatische Binnenstörungen nicht operiert	23	
	b. nichttraumatischer chronischer Hydrops (Synovitis)	35 (36)	58 (59)
			223

The figures in parentheses are those ascertained by postinvestigation.

Burckhardt divides his cases into four groups, of which the first, "*Sonstige Erkrankungen*", comprises cases where the diagnosis was certain,—arthritis deformans, syphilis, tumors, etc.,—but also some "quite doubtful cases and, finally, a couple of insignificant cases that had no clinical importance",—that is to say, cases which in Johansson's and my statistics would have been relegated to "*gonitis incertae causae*". Patients belonging to this group we find also in Burckhardt's Group IV, *a.* and *b.* which contains altogether fifty-nine cases, making thirty-one and five-tenths per cent. of all non-tuberculous gonites and twenty-six and five-tenths per cent. of the total number. *Gonitis incertae causae* is thus considerably more frequent both in Johansson's and in Burckhardt's statistics than in mine.

Now as regards the cases which in my statistics are designated as "*gonitis incertae causae*", the following brief remarks may be made: Syphilis can be barred out with certainty in all cases except five, where there is a possibility that a syphilitic infection existed or a mixed infection with syphilis.

That among my cases of *gonitis incertae causae* there are also some—but not very many—in the category which Burckhardt calls "*traumatische Binnenstörungen*" can hardly be denied. But the great majority of my cases of *gonitis incertae causae* coincide with those which Burckhardt has here entered under the symptomatic diagnosis "*synovitis chronica*". As the name implies, they are characterized by a more or less marked thickening of the capsule with a hydrops likewise more or less pronounced. We, therefore, are dealing with a tumor albus or a hydrops chronicus, depending

on which of these symptoms is the more prominent. The lesion is either unilateral or (and more often) bilateral, in most cases quite indolent, with free, or at any rate remarkably good, mobility. It occurs most frequently in adults, but also in children; six of my patients were children.

Thus there occurs—as here especially emphasized—, both in children and in adults, a bilateral indolent dropsy of the knee joint, undoubtedly not of syphilitic nature. Roentgenologically we find in some of these cases a pronounced maculate atrophy.

These forms of synovitis are doubtless not indentical in their etiology. Some cases seem to be post-traumatic, while others—especially of course the bilateral—are not so. Particularly in these latter cases we must also bear in mind the possibility of a focal infection—especially of tonsillar or dental origin.

As regards the relationship to tuberculosis—and this applies of course not only to these pronouncedly synovial forms but also to all other forms of *gonitis incertae causae*—, such an etiology obviously can be precluded with certainty in the cases that are absolutely tuberculin-negative.

Another and more difficult question is whether in tuberculosis-infected individuals, *where no other infection can be demonstrated*, we can entirely reject the possibility that there nevertheless exists a tuberculous affection of the knee, even though tuberculosis cannot be microscopically detected in the synovia that has been removed. It must here be remembered that, in addition to the specific tissue changes, tuberculosis also can occasion changes of quite non-specific nature, in the form of an ordinary chronic inflammation of exudative character. It is such entirely "non-specific tissue changes"—Poncet's "*tuberculose inflammatoire*"—that form the pathologico-anatomical foundation for his "*rhumatisme tuberculeux*", which can occur as a mono-articular, bi-articular or polyarticular affection.[33]

To ascertain that such a "tuberculous rheumatism" really is present is therefore not possible by pathologico-anatomical means. It is the *clinical observations* that have supplied the proof with a probability approaching certainty. It is a clinical and not a pathologico-anatomical diagnosis. "The tuberculous rheumatism is the offspring of clinical observation. To clinical study I likewise owe the discovery of the inflammatory tuberculosis, of which the articular tuberculous rheumatism is only one of the manifestations in the joints." Poncet has taken these words as motto for his great work on "Tuberculous Rheumatism", a conception that has gradually won general recognition also in Germany (Melchior, Strauz, Rhonheimer, Baudelier, Roepke, Gorke, Ruescher and others).

In the Coast Hospital I have in the course of years had an opportunity of observing a large number of cases which, in their clinical course, fully confirmed Poncet's hypothesis and which may be explained by means thereof. This applies particularly to the pathology of the knee joint. In the cases studied are found a number of patients who, together with signs of manifest tuberculosis (pulmonary tuberculosis, suppurating glands), presented a unilateral or, more often, bilateral affection of the knee, with or

without hydrops, or in whom such a lesion had arisen in immediate succession to pleurisy or erythema nodosum, or where manifest tuberculosis occurred in the history of the illness.

In these cases, always refractory to salicyl, and where *no other cause* of the affection of the knee could be demonstrated, it seems justifiable to assume that the lesion is due to the tuberculous infection, *in spite of negative guinea-pig test and notwithstanding that microscopic examination of the diseased synovia only revealed "chronic inflammation without any specificity whatsoever".*

The matter is more difficult to decide in cases where no manifest tuberculosis is present and where only some enlarged mediastinal glands, or perhaps only a positive Pirquet, betray a tuberculous infection. When in such cases no other infection nor any other cause of the affection of the knee can be found, *we cannot, in my opinion, reject the possibility of the lesion being due to the tuberculous infection.*

If this assumption is correct (diagnostic aids not at present available will perhaps some day make clear this situation also), tuberculosis must be held responsible for many cases of gonitis which to-day are ascribed to "unknown causes" and lie concealed under the *symptomatic* diagnosis.

My principal purpose in this article, however, has been not to argue in favor of a more or less justified hypothesis respecting the etiological situation in these gonites "incertae causae", but first and foremost to point out how large is the number of knee-joint affections that in our every-day practice we treat as tuberculous, *but which in reality are not so.* The investigations made at Stavern Coast Hospital fully confirm the findings of other investigators in this respect.

In the next place, my investigations have shown—likewise in conformity with those of other authors—that, in spite of all our older and more modern diagnostic resources, *there is still to be found in our statistics a large deficit with respect to reliable diagnoses.* In Sven Johansson's and Burckhardt's statistics this deficit amounted to more than one-fourth of all the cases, in mine to more than one-sixth, and in Sorrel's to about one-seventh. Farther than this we have not yet advanced.

For the doctors in earlier times things were in many respects considerably easier than for us. For them a tumor albus was tuberculosis and a chronic hydrops genus was "water on the knee", and both they themselves and their patients were satisfied with that knowledge. It is otherwise now; both we ourselves and our patients of to-day demand to know more. But our search for more knowledge gives rise to doubt with all its torments; because, instead of greater clarity and greater certainty, it often begets only perplexity and uncertainty; and involuntarily we come to think of what was said by the ancient philosopher thousands of years ago: "Where there is much wisdom, there is much vexation of mind; and he who increases knowledge increases pain".

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SPLIT-HEEL APPROACH IN OSTEOMYELITIS OF OS CALCIS*

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The surgical approach to lesions of the os calcis presents considerable difficulty. This is especially true in cases of extensive destruction of the interior of the bone due to osteomyelitis, and in the cases in which adjacent joints or tarsal bones are involved. In all but smaller circumscribed lesions the usual medial or lateral approaches are apt to give inadequate exposure, with the result of recurrence or persisting sinuses due to incomplete removal of diseased bone.

The following series of eleven cases of osteomyelitis of the os calcis, nine pyogenic and two tuberculous, some of the pyogenic cases with involvement of adjacent joints and tarsal bones, is reported because radical treatment by the split or cloven-heel method has been eminently satisfactory, there having been no persisting sinuses and but one recurrence to date, the latter occurring in one of the cases of tuberculosis.

In any consideration of the treatment of osteomyelitis careful distinction must be made between the acute type and the chronic type. In the acute type with marked constitutional symptoms early drainage is imperative. This primary or drainage operation often resolves itself into a simple stab wound for the escape of pus. Some of the cases reach the surgeon after spontaneous rupture of abscess, in which event drainage operation may be unnecessary. After the acute symptoms have subsided, secondary operation is usually indicated for the removal of sequestra. In this consideration only the secondary or radical operation is considered.

Undoubtedly the comparative infrequency of disease of the os calcis has been responsible for the lack of development of any procedure more or less generally applicable. In the case of the more frequently involved long bones, definite surgical approaches have been developed and these have become fairly well standardized for all but atypical lesions and locations. The approaches to the long bones have been developed to meet the following definite demands:—(1) adequate exposure to allow removal of all dead bone; (2) the provision, so far as possible, of a shallow wound with shelving edges to allow gradual filling in of soft parts,—in other words, the avoidance of overhanging ledges of bone and of tunnels in the bone; (3) avoidance of separation of the periosteum beyond requirements as above; (4) reflection of soft parts, including periosteum, in a single thick flap on each side in order to lessen the opportunity for extension of the infection in these flaps or for interference with their circulation; (5) avoidance of injury of important soft parts.

*Presented at the Annual Meeting of the American Orthopaedic Association, Memphis, Tennessee, April 17, 1931.

These well founded and generally accepted demands are met satisfactorily in osteomyelitis of the os calcis by the split-heel approach.

PATHOLOGICAL CONSIDERATIONS

In most of the cases reported there was a central lesion involving a greater or lesser amount of cancellous bone, while the cortical bone was either entirely uninvolved or merely perforated by the sinuses. In some the pathological process had invaded the astragalocalcaneal joint as well as the mid-tarsal joint. In no case was the os calcis found denuded and lying in a pool of pus. In no case was there an involucrum surrounding the os calcis. The same holds true for the astragalus or other tarsal bones found involved in some of the cases here reported. While it would be unwise to conclude from this small series that involucrum formation does not occur in the tarsal bones, it is safe to say that it must be an unusual event. The writer has had no experience with pyogenic osteomyelitis of the carpal bones, but it would be interesting to compare bone-repair processes in the carpals and the tarsus in this respect. In no case was there extensive periosteal separation with large areas of dead cortical bone. This is in striking contrast to the pathological picture found in the long bones,—especially in children, where pus may strip the periosteum from large areas of bone. No explanation of this lack of periosteal separation was found in the literature. It is probably due to the fact that the periosteum of the os calcis, serving as it does for the attachment of numerous strong muscles and tendons, is attached to this bone with unusual firmness. The writer believes that in any bone, long or short, pus forms in small, rather than in large quantities in the cancellous bone. It seems probable, also, that only small quantities penetrate the cortex through the haversian canals, but once the infection is planted under the periosteum, pus production at this site is both abundant and rapid. In the long bones where the periosteum strips readily, large areas are rapidly denuded. In the os calcis, on the other hand, the periosteum, because of its firm attachment, is perforated rather than stripped and this accounts for the lack of much cortical destruction and the lack of involucrum formation. If it is true that an involucrum does not form in these cases, then radical operation should follow the drainage operation at an early date,—in fact as soon as the patient has recovered from the acute toxaemia—for fear of extension of the disease. These considerations are deemed important because, if the periosteum and the cortical bone are not involved, stripping of the periosteum and sacrifice of cortical bone at operation are unnecessary.

While purely conjectural, the author believes that when bacteraemia occurs, this is due to the sudden injection, as with a syringe, of an accumulation of subperiosteal pus under tension into a vein, torn and gaping through the stripping process.

The first patient operated upon by the split-heel method was a girl eleven years old. Late in September 1922 she had run a sand bur into her

left heel. Within six days her entire foot and ankle were red, swollen, and painful. Incision for drainage had been made over the heel and external malleolus by her family physician. She was seen for the first time by the writer late in the evening of November 21, 1922. Clinical and x-ray evidence indicated an extensive and apparently progressive involvement of the os calcis and adjacent tarsal bones. There was a discharging sinus over the heel, and motion at the ankle was painful. In order to avoid further extension, operation was performed the next morning. Because of the already existing, partially healed incision from the previous drainage operation, with discharging fistula, as well as the marked and diffuse swelling of the entire heel, the mid-plantar incision was chosen as the most direct route. By means of this the heel was in effect bisected. A chisel was not necessary, the only portions of the os calcis remaining being fragments of the cortical shell. Even then, however, retraction of the two halves did not give the desired access. Accordingly the lower three or four centimeters of the Achilles tendon were split in the midline. When this was done, the two halves of the heel could be retracted like an open book. The undesirability of the plantar scar received no consideration because of the gravity of the situation. Moreover, in the writer's experience in removal of calcaneal spurs, it was not to be feared. At any rate, exposure was eminently satisfactory. Sequestra were removed and the entire interior of the os calcis and all but the upper articular portion of the astragalus were cleared of granulation tissue with gauze or curet, the wound packed with glycerin gauze, and the limb immobilized on an anterior molded plaster. Dakin's dressings replaced the glycerin pack in four days. Later sterile adhesive strips assisted in closure of the wound. Final healing occurred about four months after operation.

After this experience no hesitation was felt in applying the method in eight additional cases coming under the care of the writer since that time. The technique in these later cases has remained unchanged, except that the adhesive strips were discarded, and the Orr vaselin pack and immobilization in plaster cast replaced the glycerin pack and Dakin treatment. Dissections in the anatomical laboratory of the University of Wisconsin further demonstrated the feasibility. The method was described before the Clinical Orthopaedic Society, meeting in Madison in November 1929, at which time the operation was demonstrated both on a patient and on the cadaver.

TECHNIQUE

An expulsion bandage and an Esmarch bandage to render and to keep the part bloodless are of distinct advantage in the study of the pathology. With the patient lying face down and a support under the ankle, an incision is made beginning on the plantar surface of the foot directly opposite the tuberosity of the fifth metatarsal bone, on a line bisecting the heel and the middle toe, then extending over the heel and splitting the Achilles tendon in the lower three or four centimeters. This incision extends through the skin

and plantar aponeurosis. It lies between the abductor of the small toe and the short flexors of the toes, though no special effort is made to identify these structures. The external plantar artery and nerve are seen in the distal angle of the wound. These structures are carefully retracted to the medial side. A few unimportant vessels to the abductor of the small toe are sacrificed. The fibers of the plantar quadratus muscle are exposed and split longitudinally, also the long plantar ligament. The os calcis is now divided with a broad chisel into an inner and outer half, the chisel passing obliquely from behind forward and toward the dorsum so far as is necessary to expose the lesion. If the process is confined to the epiphyseal region as it not infrequently is in children, the incision may be less extensive. If the astragalocalcaneal joint is involved, the os calcis is completely divided, retraction of the two halves completely exposing the interior of the bone and

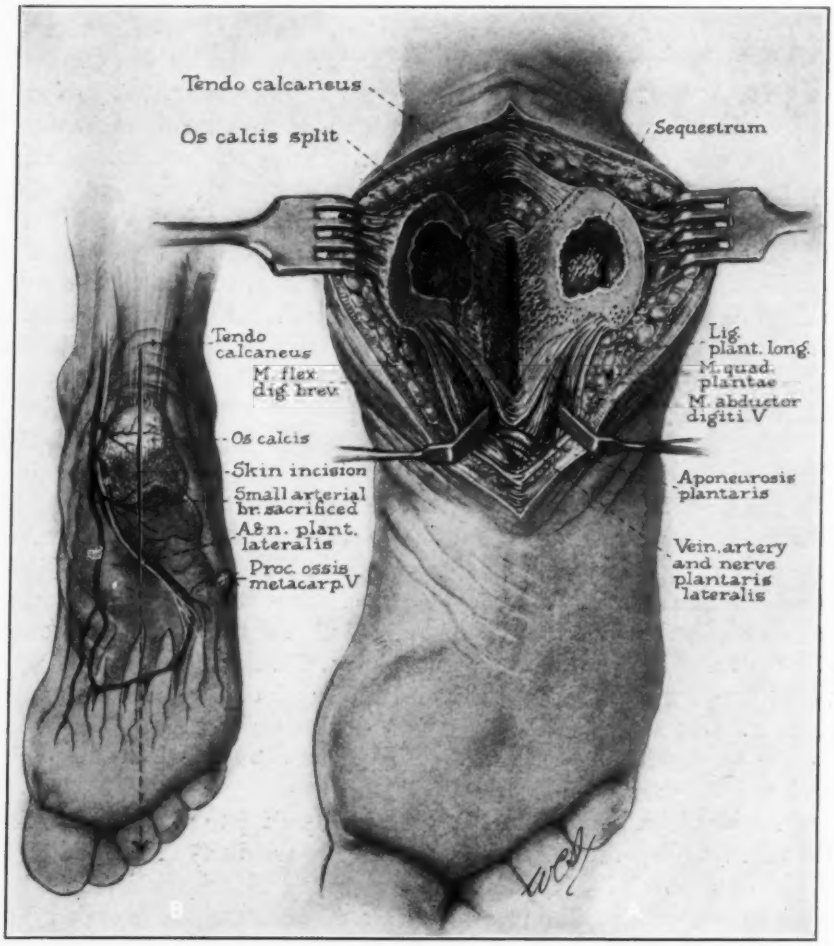

FIG. 1

A. Drawing from cadaver. The bone lesion is schematic.
B. Sketch showing line of incision and relation to plantar artery and nerve.

at the same time giving ready access to the joint. In such cases ankylosis is inevitable, no matter what course is taken. It is an easy matter now to remove all dead bone and granulation tissue. As a rule the cortex is not involved except where sinuses have pierced it. Sinuses are disregarded in planning the incision. A strand of dry gauze drawn through all sinuses from within outwards, will serve to remove the granulation tissue along the tract. The wound is left wide open, not even the angles being sutured. After filling the wound with a fairly stiff vaselin, a plaster cast is applied. Dressings are made at intervals of one to three weeks until final healing.

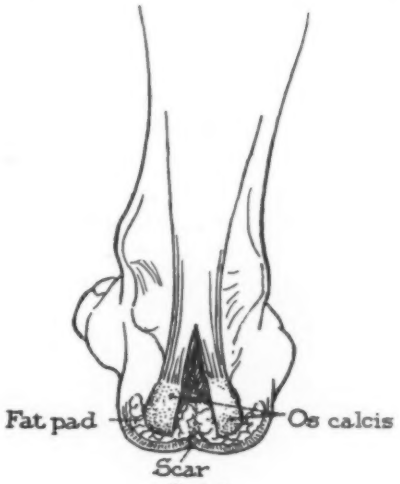

FIG. 2

Sketch showing scar partially retracted in cleft, resulting in two cushions well adapted for weight-bearing without pain.

In looking over the literature one is impressed with the great variety of procedures employed, ranging all the way from simple curettage through enlarged fistulous tracts to amputation. Granting that all of these types of operation may conceivably be indicated in particular cases, the objection seems justified that in some of them exposure is inadequate, especially when adjacent tarsal bones and joints are involved. On the other hand, excision of the entire os calcis is probably very rarely necessary.

FIG. 3

E. D. Case 2. X-ray just before operation showing extensive tarsal involvement and large sequestra in os calcis.

Not until recently, in a final review of literature, did the writer come upon Landerer's account in 1895 of a procedure identical with his own. However no one apparently has followed this technique and only two brief references were found, one of which warned against the plantar incision. Roquet, in 1922, apparently also without knowledge of Landerer's contribution, used a short plantar incision in the case of a lesion involving the posterior portion only of the os calcis.

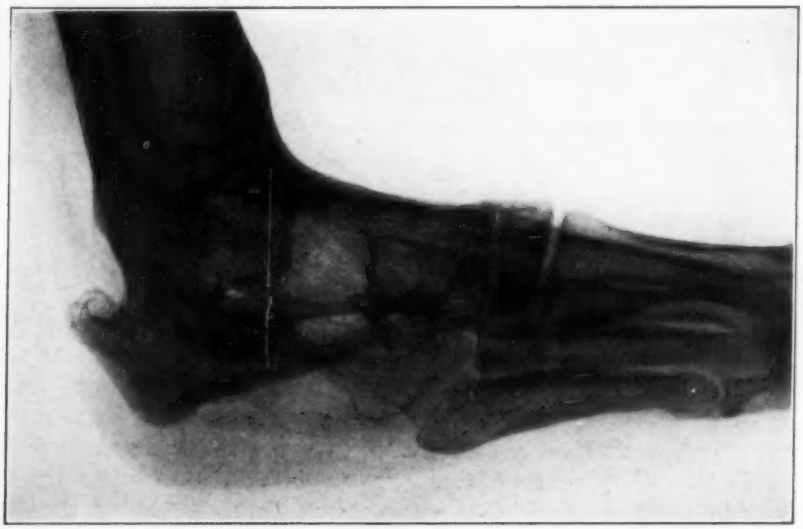

FIG. 4

E. D. Case 2. X-ray six years after operation showing fusion of ankle and tarsal joints.

FIG. 5

E. D. Case 2. Posterior oblique view showing split heel.

FIG. 6

E. D. Case 2. Six years after operation showing deeply contracted painless scar. Good weight-bearing.

CASE REPORTS

CASE 1. L. Z., female, age eleven. Admitted to Bradley Memorial Hospital, Madison, November 20, 1922. History related (page 761). Patient last seen on September 2, 1925. The scar was not painful and patient was able to walk on the toes and on the heels normally. Trace of limp and difficulty in walking with feet in supination because of subastragalar fusion.

CASE 2. E. D., female, age eleven. Admitted to Wisconsin General Hospital on January 20, 1925, eight days after onset of illness. At this time there was discoloration and swelling involving the entire foot and lower third of the leg with fluctuation above ankle and numerous sinuses. Gradual subsidence of acute symptoms following additional free incisions on February 24. March 25, radical split-heel operation. Removal of sequestrum consisting of about one-half of the body of the os calcis. Considerable involvement of astragalus and scaphoid with sequestrum formation. Three sinuses on dorsum of the foot were converted into one larger one admitting two fingers. Wound left wide open and packed with dry gauze. Wound repacked same evening by house officer because of considerable oozing. Blood transfusion of 500 cubic centimeters given. Complications were osteomyelitis of the left olecranon, left inner malleolus, right humerus, and septic arthritis of the left elbow and of the right shoulder. Discharged July 29, 1925 with all wounds closed. Final observation March 25, 1931: walks well in shoes, but in bare feet is unable to bring heel down because of equinus of ten degrees. This

FIG. 7

A. W. Case 3. X-ray just before operation showing two chronic bone abscesses and calcaneal spur.

necessitates a pad in the heel. Scar not tender. X-ray shows astragalotibial, subastragalar, and mid-tarsal fusion.

Case 3. A. W., female, aged thirty-nine. Admitted to Wisconsin General Hospital on December 1, 1925. Patient developed osteomyelitis of the right ankle following wrench of the foot in 1903. Complications at the time were abscesses over the sternum and left leg, also marked cellulitis of the right calf, requiring wide incision. This was followed by deep scar formation shown in photograph. Sequestrum removed from heel in 1909 resulted in closure of sinus. Heel-cord lengthening same year. Recurrence of abscess about right ankle in September 1925. On admission, December 1, 1925, right ankle showed numerous scars from previous operations and a discharging sinus on the outer aspect of the right ankle. There was equinus of fifteen degrees with only a trace of motion at the ankle joint, none at the subastragalar joint. X-rays showed fusion of the astragalus and os calcis and two rounded, dark areas one and five-tenths and two centimeters in diameter respectively. There was also a definite calcaneal spur. Diagnosis: chronic bone abscesses and spur of the right os calcis. Radical heel operation performed December 3, 1925. Discharged on December 20. January 26, 1926, readmitted for renewal of cast; wound practically closed. February 16, 1926, cast removed; few small granulating wounds. Final observation March 25, 1931, showed moderate limp due to equinus of fifteen degrees and subastragalar fusion. No recurrence. Plantar tenderness present due to spur which should have been removed at operation. Scar is not tender.

Fig. 8

A. W. Case 3. Showing scar over heel ten months after operation.

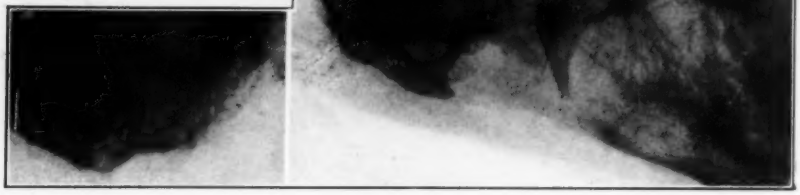

Fig. 9

A. W. Case 3. X-ray over five years after operation.

CASE 4. R. W., patient at Columbia Hospital, Milwaukee. Sequestrum consisted of destroyed posterior portion of os calcis. (See Table I.) No additional data of importance.

CASE 5. W. S., male, age thirty-three. Onset with sprain of left foot by playing baseball in June 1927. Mild symptoms until September 5, 1927, when pain and swelling were observed in left ankle. First seen by writer at Misericordia Hospital early in October. At this time there was moderate swelling and some discharge from several sinuses following incision for drainage. X-ray showed considerable sequestration. October 11, 1927, a radical operation was performed according to usual technique. Cast and dressings changed about once a month until April 16, 1928, when wound was almost closed. A slight seropurulent discharge continued until January 3, 1929, when a rigid brace was supplied because of a painful traumatic arthritis of ankle joint, probably due to injury of lower anterior margin of tibia. Final observation, August 29, 1929: condition very satisfactory. Brace however still necessary because of traumatic arthritis of ankle joint. Plantar scar not painful. X-ray shows fusion of remains of os calcis, astragalus, and cuboid. Oblique posterior view shows unequal halves of os calcis. Pad in shoe required to equalize pressure during weight-bearing.

FIG. 10

S. J. Case 9. X-ray just prior to operation showing large bone abscess in os calcis.

CASE 6. R. P., female, age eleven, Columbia Hospital, Milwaukee. On first examination, December 6, 1927, there was slight swelling of the left ankle and tibia, purplish discoloration about malleoli and heel, marked tenderness over heel but ankle motion free. X-ray showed lesion involving epiphyseal region. Diagnosis: osteomyelitis of the left os calcis. December 8, 1927, radical operation, usual technique. Cultures showed a hemolytic streptococcus. The epiphysis was necrotic and removed *in toto*. Suppuration in plantar bursa. Walls of bursa much thickened. Usual after-treatment. Wound found completely healed on removal of fourth cast, March 20, 1928. Pathological diagnosis: chronic osteomyelitis; no evidence of tuberculosis. Recovery uneventful. Last observation August 20, 1928: scar perfectly healed. Walked well without pain. No disability.

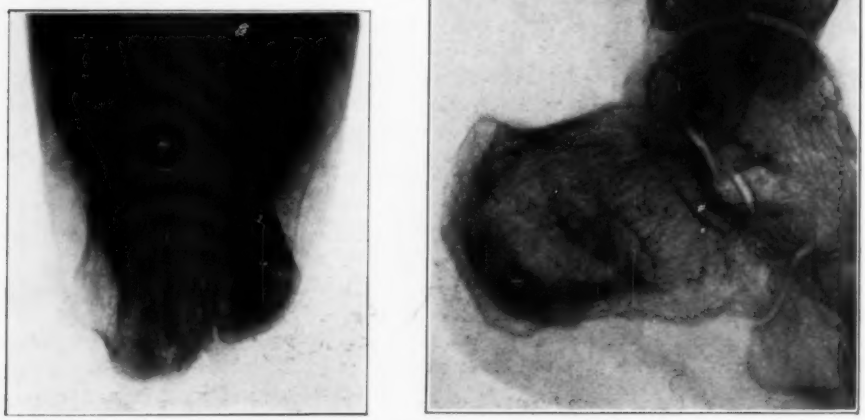

FIG. 11

S. J. Case 9. X-ray, lateral and posterior oblique views, one year and five months after operation.

CASE 7. P. G., female, age one and one-half. Perfectly well until July 15, 1928, when mother noticed that child limped. One week later slight swelling was apparent. Treated as sprain until October 5, 1928. On examination, October 12, swelling and tenderness of both right heel and left leg above ankle were noted. On basis of physical

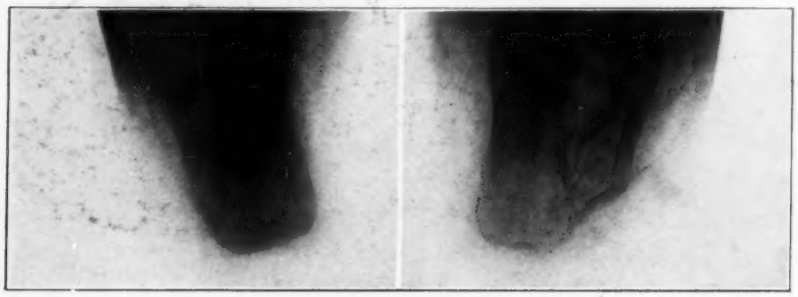

FIG. 12

P. G. Case 7. X-ray two and one-half years after operation. Posterior oblique view of both heels. Note recurrence of tuberculous abscess on right.

examination and x-ray study a diagnosis was made of osteomyelitis of right os calcis and left tibia. Operation on October 16, 1928, disclosed a subcutaneous abscess above the left ankle with small bone defect filled with granulation tissue. Culture negative. Pathological diagnosis: chronic inflammation, no evidence of tuberculosis. Operation, October 16, split-heel technique as described. Practically entire diaphysis of os calcis sequestrated. Convalescence uneventful. December 22, 1928, entirely healed. September 3, 1930, recurrence of pain, limp, and local temperature. March 22, 1931, examination indicated recurrence of lesion in right os calcis. X-ray shows almond-sized area of rarefaction regarded as tuberculous abscess in cleft between the split halves of the os calcis.

CASE 8. W. S., male, age seven. Admitted to Wisconsin General Hospital on February 7, 1926, with multiple discharging tuberculous lesions. The onset was gradual in January 1925, with swelling of the left foot. In December 1925 the right foot became involved. Incision of abscesses followed by formation of sinuses which discharged intermittently to the time of admission. Operation, split-heel method, on right foot Decem-

FIG. 13

V. W. Case 11. X-ray (lateral view), eleven and one-half months after onset, showing extensive involvement of os calcis and cuboid. Note complete absence of involucrum.

ber 19, 1928; usual technique. There was considerable involvement of the os calcis with extension into astragalocalcaneal joint. April 10, 1929, all sinuses closed. April 24, 1929, discharged. Small granulating area in depth of heel incision, reported closed two months later. Diagnosis: tuberculosis of the right os calcis and astragalocalcaneal joint. District nurse reported slight drainage to about June 1929. Perfectly well since.

Case 9. S. J., female, age sixteen. Admitted to Wisconsin General Hospital October 1, 1929. Past history: multiple osteomyelitis, also septic arthritis of both sacro-iliac joints, resulting in bony ankylosis several years previously. Onset of acute symptoms in right heel on September 15, 1929. Incision for drainage followed by prompt relief of acute symptoms. X-ray, October 19, showed extensive destruction of interior of os calcis. Operation, October 26, 1929, by split-heel method; usual technique. The interior of the os calcis was filled with granulation tissue. This was curetted and the abrupt edges cut down with rongeur leaving a cavity of considerable size. Usual after-treatment. Discharged November 11, 1929, and completely healed February 24, 1930. Last observation March 25, 1931. Walks without limp in shoes. In bare feet equinus of ten degrees prevents bearing weight on heel. Right heel broader than left. Scar not painful. No recurrence.

Case 10. J. B., female, age seven. Reported by courtesy of Dr. H. C. Schumm. Onset about December 10, 1923, with limp, severe pain, and swelling in left ankle. Examination on February 10, 1924, showed marked swelling of right ankle and four sinuses. Radical operation using technique as described above. Almost the entire os calcis was involved, numerous sequestra as well as the outer half of the os calcis removed, leaving only periosteum on this side.

Case 11. V. W., female, age twenty-seven. Reported by courtesy of Dr. R. S. Reich of Cleveland. Onset November 1, 1928. Incision for drainage November 5. Radical operation, January 31, 1929. Final healing, May 1930. In this case there was extensive involvement of the os calcis as well as of the cuboid. According to a final report by Dr. Reich, dated March 24, 1931, the patient has been working and walking on her heel without any pain or disability whatsoever. There is a bilateral varus deformity in this case which Dr. Reich believes is not related to the osteomyelitis of the heel. Cultures showed staphylococcus aureus.

Fig. 14

V. W. Case 11. X-ray (lateral view), five months after complete healing, showing subastragalar fusion and defect in cuboid.

TABLE I

No.	Initial	Age	Sex	Mode of Infection	Organism	Site and Extent	Date of Radical Operation	Date of Wound Healing	Result	Remarks
1	L.Z.	11	F	Local, infection sand bur	Pyogenic	L Entire calcaneus, subastragalar joint	11/22/22	3/7/23	Slight limp, painless scar, subastragalar motion limited	Osteomyelitis 12th dors. vert. Healed 12-30-25
2	E.D.	11	F	Vaccination, bacteraemia hematogenous	Staph.	R Entire calcaneus, astragalus, scaphoid, and joints	3/25/25	7/29/25	Painless scar, ankylosis of ankle and tarsal joints	Multiple lesions
3	A.W.	39	F	Hematogenous, following a sprain	Pyogenic	R 2 chronic bone abscesses in calcaneus	12/3/25	2/16/26	Slight limp, plantar tenderness over spur	Removal of spur omitted
4	R.W.	9	M	Abrasion followed by local infection	Staph.	L Tuber calcanei	1/7/26	3/5/26	No limp, painless, non-adherent scar	None
5	W.S.	33	M	Hematogenous 3 months following sprain	Staph.	L Entire calcaneus	10/11/27	1/3/29	Slight limp, painless scar *	Complicating traumatic arthritis left ankle
6	R.P.	7	F	Hematogenous	Hemolytic Strep.	L Limited to apophysis	12/8/27	4/8/28	No limp, painless scar	Slight limp with fatigue
7	P.G.	1.5	F	Insidious onset	Tbc.	R Tuber calcanei	10/16/28	2/9/29	Complete temporary recovery †	Tuberculosis, left tibia
8	W.S.	7	M	Insidious onset	Tbc.	R Calcaneus and astragalo-calcaneal joint	12/19/28	4/10/29	Slight limp, painless scar, subastragalar fusion	Multiple lesions
9	S.J.	16	F	Hematogenous	Pyogenic	L Tuber calcanei	10/26/29	2/24/30	Painless scar	Lesions of left tibia and right femur
10	J.B.	7	F	Hematogenous	Pyogenic	L Almost entire calcaneus	2/11/24	6/1/24	No limp, painless scar	Lateral sinus persisted an additional 7 months
11	V.W.	27	F		Staph.	Os calcis, astragalus, and cuboid	1/31/29	May 1930	Painless scar fused, subastragaloid joint	

*Heel halves of unequal height; pad in shoe. Brace worn because of astragalotibial involvement.
†Recurrence—tuberculous abscess in cleft of right os calcis, seventeen months after healing.

COMMENTS

The method described provides satisfactory exposure in dealing with lesions of the os calcis as well as of adjacent tarsal bones and joints.

Periosteal stripping and removal of healthy cortical bone is avoided.

Complete excision, advocated by many, has not been necessary in any of the present series of cases, in spite of extensive involvement.

A minimum of healthy cancellous bone is sacrificed and tunneling is avoided.

Healing has been satisfactory, patients frequently being discharged to their homes between plaster dressings for periods of several weeks.

Sinuses should be disregarded in the incision, as they invariably close, provided all dead bone is removed.

The plantar scar is so deeply situated that the plantar tissues form two thick cushions well adapted to weight-bearing without pain.

No plastic operation has been necessary in any case.

No secondary operations have been necessary to date, although in one case there is recurrence of a chronic tuberculous abscess after twenty-three months of apparent recovery. It is probable that further surgery will be necessary in this case.

A difference in the split halves, both as to size and elevation, appears sometimes to be unavoidable, but no difficulty has arisen from this source beyond the need of a pad in the shoe, in two cases.

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AN OPERATION FOR THE CORRECTION OF EXTREMELY RELAXED FLAT FEET*

BY MICHAEL HOKE, M.D., ATLANTA, GEORGIA

Experienced orthopaedic surgeons will identify these flat feet among the varied types of flat feet by their qualities, and the failure to correct them by the conservative methods of treatment,—exercises, arch supports, and corrective shoes.

They are very flat, elongated, badly pronated, moderately abducted, and extremely flexible in the mid-tarsal joints and metatarsotarsal joints. The flexibility is greatest in the scaphoid-cuneiform and internal middle cuneiform joints; this is of paramount importance since it interferes with the coordinated arch-lifting power of the tibialis posticus, tibialis anticus, and flexor hallucis longus.

I have observed some of these feet for years, trying at the same time to correct them by non operative means, only to see them remain as they were in the beginning,—very flat and very flexible. Possibly some of them are congenital in origin, but this cannot be decided, for one does not see them as patients until years after infancy has been passed. I think they are a result of walking for a long time with the feet abducted and pronated, for most infants begin to walk in this manner. Children who do not instinctively change to an adducted foot position and learn quite unconsciously to use the tibialis posticus, tibialis anticus, and flexor hallucis longus simultaneously as the foot strikes the ground when walking, continue to stretch the plantar and interosseus ligaments at each step.

The human foot can be held up in an arched position only by the power of muscles acting coordinately the instant weight is borne, presupposing that there is nothing to hinder the component bones from taking a normal position, and that the Achilles tendon is not short. The mechanism of this is shown in Figure 1 which is a lateral roentgenogram of a good foot, taken while the person was standing. The body weight—arrow *a*—is applied to the astragalus by the end of the tibia. This weight force splits into component forces *b* and *c*: *c* is transmitted to the os calcis and has little flattening effect, but it tends to heel pronation; *b* is transmitted forward in the direction of the axis of the neck of the astragalus, and is applied by the head of this bone to the scaphoid and the calcaneoscaphoid ligament. The astragaloscaphoid joint and the subastragaloid joint are the movable areas which permit the flattening of the foot, and at the same time the stretching of the ligaments in the mid-tarsal joints if this force (*b*) is not checked by the coordinate use of the power of the tibialis posticus, tibialis

*Presented at the meeting of the American Orthopaedic Association, Memphis, Tennessee, April 17, 1931.

FIG. 1

anticus, and flexor hallucis longus. The tibialis posticus pulls in the direction of the arrow *d*, Figure 1, opposite to the force *b*. The function of this muscle is to adduct the foot, to hold the scaphoid bone tightly against the head of the astragalus and the scaphoid tubercle somewhat under the head of the astragalus, the latter bone being beveled underneath to permit this. The tibialis anticus is attached to the skeleton anterior to the scaphoid-cuneiform joint and pulls upward (arrow *e*). How does the tibialis anticus oppose the force *b*? It does it by lifting the bone lever made up of the scaphoid and internal cuneiform bones. But this power, used in this way, can be effective only if the tibialis posticus holds the scaphoid tightly against the head of the astragalus, the scaphoid tubercle somewhat under it, and if the scaphoid-cuneiform joint is a tight joint with only a little motion in it. If the foot, when weight is borne upon it, is only moderately abducted, and the scaphoid-cuneiform joint is loose, the effective arch-lifting power of the tibialis anticus is markedly decreased. How does the flexor hallucis longus oppose the force *b* and help to hold up the arch? Its tendon, winding under the sustentaculum tali, using this for a fulcrum, courses under the inner row of bones like a string to a bow, and, when it is taut, lifts the arch.

The mechanical details of this follow: When the great toe is pressed against the sole of the shoe by the flexor muscle, it sends a force (*f*) up the shaft of the first metatarsal. There is a tubercle on the inferior surface of the posterior end of the bone, and this tubercle is directed downward. When the toe is flexed, the tubercle impinges against the internal cuneiform. From this point of contact the tuberous border of the internal cuneiform winds inward and upward. The force *f* is transmitted to the scaphoid, the tubercle of which is directed inward. The spiral arrangement of these

tubercles converts the force *f* into a torque, which finally acts in the direction of *f*, marked on the scaphoid. This force is markedly decreased if there is a great deal of motion in the scaphoid-cuneiform and internal middle cuneiform joints. There can be no mechanical substitutes for the power of these three muscles. For the arch to be held up, these three muscles—the tibialis posticus, tibialis anticus, and flexor hallucis longus—must be tightened simultaneously the instant the foot strikes the ground when walking. If this is not done, the astragalus tilts downward and the force *b*, not properly resisted, puts all the strain upon the mid-tarsal segment of the foot; the ligaments are stretched more and more, and ultimately the joints are too loose for the muscle power to be effective, even if used coordinately.

One more factor completes the vicious circle in the development of the flexible flat foot. If the foot is used in an abducted position for years, the Achilles tendon is not stretched at each step. Gradually it becomes so short that the astragalus is permanently tilted downward, and the anterior ends of the metatarsal bones can be on a level with the tubercle of the os calcis, the patient standing, only if the dorsiflexion of the anterior foot takes place in the mid-tarsal joints, particularly in the scaphoid-cuneiform and internal middle cuneiform joints.

The points of major importance that one finds in these feet are: (1) a short Achilles tendon; (2) extreme flexibility of the mid-tarsal joints, particularly the scaphoid-cuneiform and internal middle cuneiform joints; (3) the relation in position of the bones as shown in Figure 2. Figure 2 is a lateral roentgenogram of a flexible flat foot, the patient standing. The flatness is evident. The astragalus is tilted downward. The upper surface of the mid-tarsal segment is a little concave instead of convex, as it

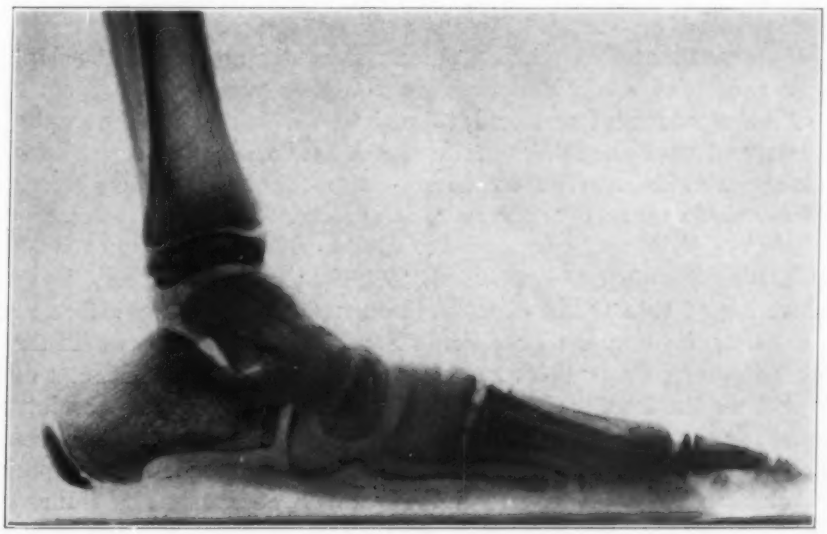

FIG. 2

should be. The foot is so pronated that only the vertical diameter of the inner row of bones is cast upon the plate. Manifestly the exhibit in Figure 2 cannot be changed into that shown in Figure 1 by exercises, arch supports, and corrective shoes.

Figure 3 is a composite drawing of a flexible flat foot showing the relation of the bones, standing, and with the anterior foot in equinus, not standing.

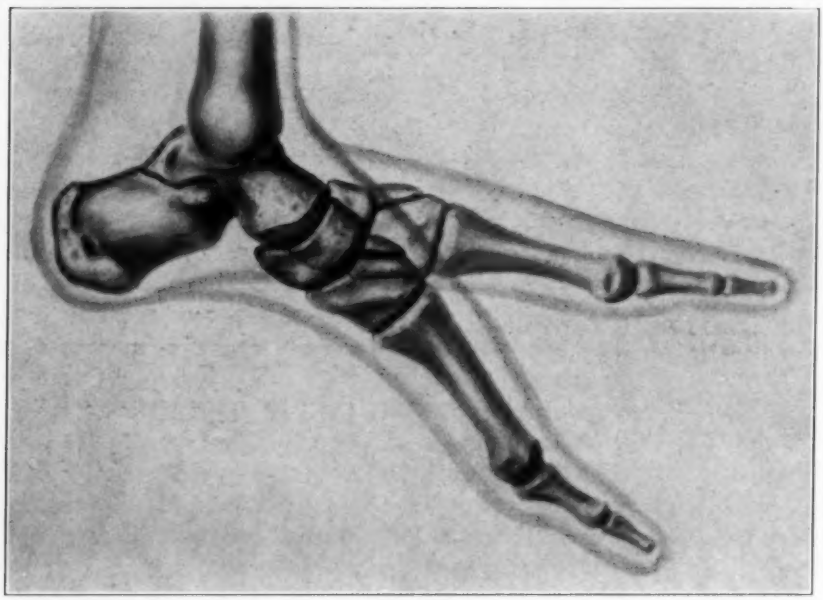

FIG. 3

It is seen that the equinus position restores the normal relationship of the bones. The operative corrective actions, therefore, are these: (1) the Achilles tendon is lengthened; (2) with the foot in equinus, the scaphoid internal and scaphoid middle cuneiform joints are stiffened by bone-grafting them; (3) a careful setting after the manner described below. The skeleton in this way is restored to the normal, and thereafter the muscles, when trained, can hold up the arch without hindrance.

Description of the operation: The Achilles tendon is dissected, leaving a covering of thin tissue (sheath) through an incision two inches long made along the inner border of the tendon. It is cut half in two, in three places, as shown by the black lines on the tendon (Fig. 4). The foot is dorsiflexed, the lengthening of the tendon occurring by tearing along the dotted line. The sheath still covers the tendon, preventing adherence of the tendon to the skin. It is also a mold that gives a round tendon after healing. The skin is sutured. Thereafter in the operation, an assistant holds the foot in equinus by grasping the anterior ends of the metatarsals. The anterior end of the first metatarsal is forcibly pressed in equinus. The scaphoid-

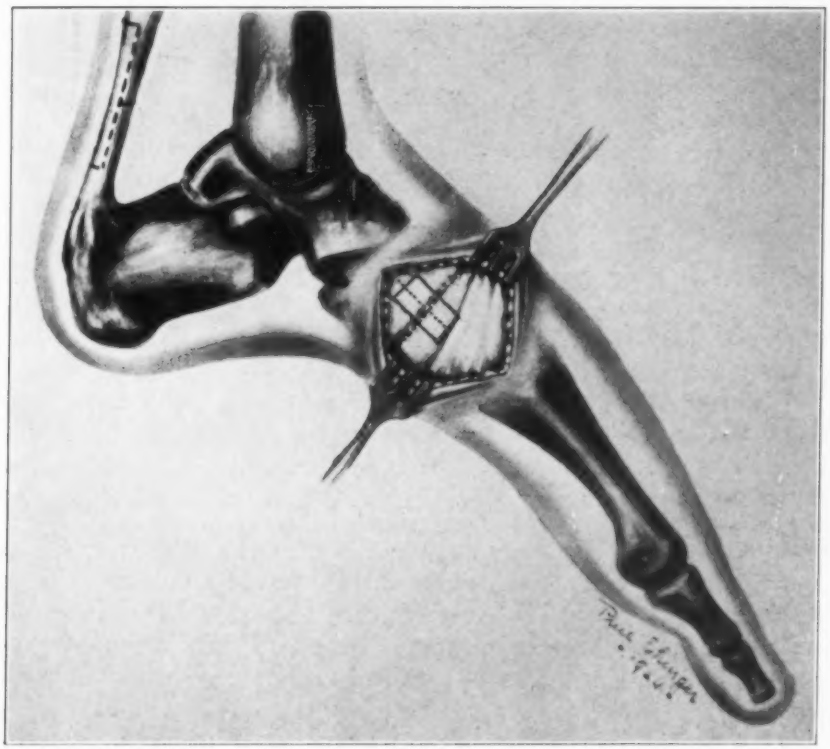

FIG. 4

cuneiform joint is opened (Fig. 4). Another incision along the longitudinal dotted line is made to the bone. The flaps are dissected from the bones. With a thin osteotome, cutting deeply, the cartilage surfaces of the contiguous parts of the scaphoid, internal and middle cuneiform bones are removed. A rectangular section of bone one-half inch deep (See black rectangle) is cut from the scaphoid and internal cuneiform bones. The pieces are taken out and cut into bits. A bone graft the size of the rectangle is taken from the tibia and driven into the rectangular receptacle; the bits of bone are packed into the deep and superficial spaces not filled by the graft. The flaps are closed over the grafts. The skin is sewed. A proper setting finishes the operation. Thin dressings are applied. A plaster splint is made as shown in Figure 5. The foot is held in equinus. The first metatarsal is

FIG. 5

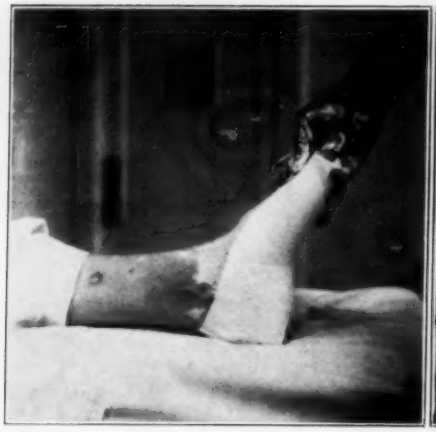

FIG. 6

FIG. 7

especially forced into equinus position by the operator's thumb pressure on the dorsal surface of the anterior end of this bone. The plaster splint is molded on the foot, the cut-out area receiving the heel. The adjacent ends fit around the heel. The plaster splint is bandaged tightly on the foot with gauze bandage. The splint is molded well under the scaphoid-cuneiform joint, and just before it hardens the posterior end of the heel is twisted inward. After the splint has hardened, the gauze bandage is removed. The edges of the plaster shoe are turned up and padding inserted underneath them. The foot skeleton is thus set so that the bones are normally related to one another in position (See Figure 6).

The foot is then dorsiflexed so that it makes a ninety-degree angle with the leg. The plaster splint prevents any change in the bone relation-

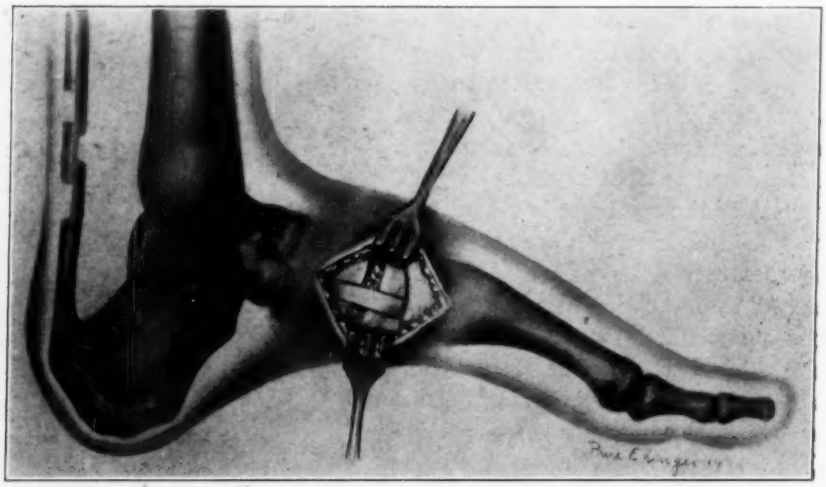

FIG. 8

ship in this action. The cast is completed to the tibial tubercle. At times it is well to apply the cast up to the mid-thigh.

Figure 7 shows the final setting in plaster. The naked foot of a person not a patient was used so that dressings would not cover the foot.

Figure 8 shows the position of the bones, the graft, and the lengthened Achilles tendon when the operation is finished and the cast applied.

Postoperative treatment: Two weeks after the operation, the cast and dressings and skin sutures are removed. The foot bones maintain their position, and a cast is applied from toes to tibial tubercle. This cast is put on as one usually applies a cast,—*i.e.*, without first applying the plaster shoe. This cast is removed after six weeks. Massage is given for a few days. A foot plate is applied, fitting well under the scaphoid-cuneiform joint. Wide-toed shoes are put on. The patient begins to walk with crutches. Massage is continued, and for two weeks the patient is drilled to contract the tibialis posticus, tibialis anticus, and the flexor hallucis longus the instant the foot touches the ground when walking. This makes a rather awkward gait. It is continued for two or three months. The plate is then removed and shoes put on that do not restrict the free use of the toes.

The problem in this type of case is the same, no matter what the age may be. Therefore, to save space, the pictorial records of only three cases, taken before and after operation, are shown. The roentgenograms of Cases 1 and 2, taken after operation, show the bones to be in normal relationship, with correction of the extreme flatness and pronation.

Case 1: L.R., aged nine years.

FIG. 9-A

Case 1. Anterior view, before operation.

FIG. 9-B

Case 1. Posterior view, before operation.

FIG. 9-C

Case 1. Anterior view, five years after operation.

FIG. 9-D

Case 1. Posterior view, five years after operation.

There are doubtful borderline cases. Such cases should, of course, have conservative treatment first, for the delay in doing the operation does not jeopardize the result if the operation has to be done later. It should not be done before eight years of age, except in rare instances. In adult feet, the foot strain is not always the sole cause of foot pain. Tarsal arthritis is present in some cases, even though it is not shown in the roentgenogram. Such feet cannot be cured by operation unless the tarsal arthritis is also cured. The arthritis must be cleared up first. I must leave the reader to his own thoughts about how to do this.

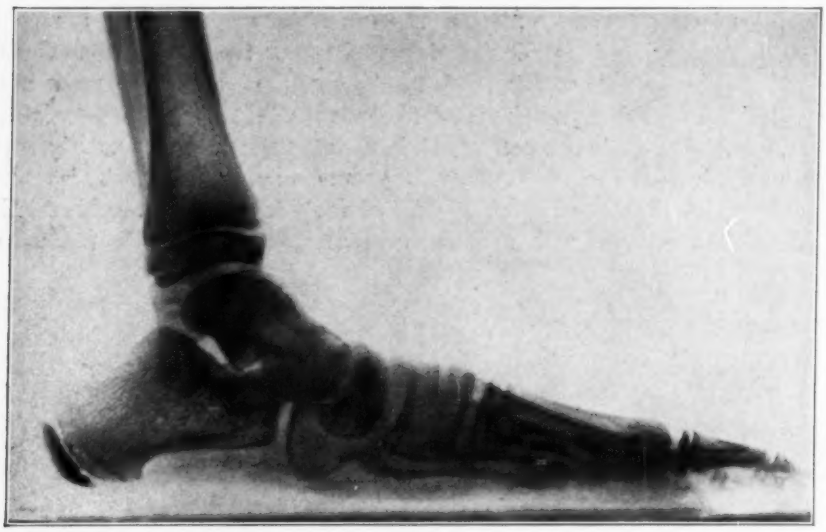

FIG. 9-E

Case 1. Lateral roentgenogram right foot before operation.

FIG. 9-F

Case 1. Lateral roentgenogram right foot five years after operation.

I did the first operation of this type in 1923. The method has been demonstrated to others often, but this is the first time it has appeared in print. It has been a satisfactory procedure.

Case 2: M.R., aged twelve years.

FIG. 10-A

Case 2. Anterior view, before operation.

FIG. 10-B

Case 2. Posterior view, before operation.

FIG. 10-C

Case 2. Anterior view, five years after operation.

FIG. 10-D

Case 2. Posterior view, five years after operation.

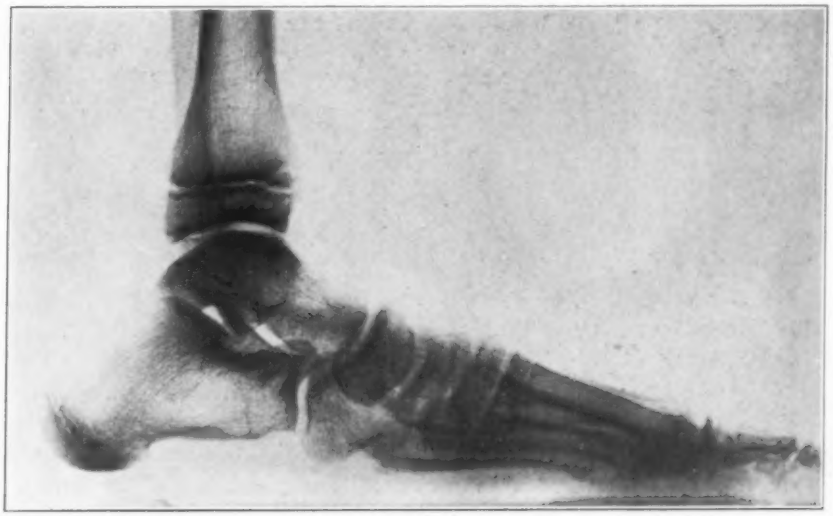

FIG. 10-E

Case 2. Lateral roentgenogram right foot before operation.

The lateral roentgenograms of the left feet before and after operation are identical in their relationship to the right. It is, therefore, not necessary to exhibit them.

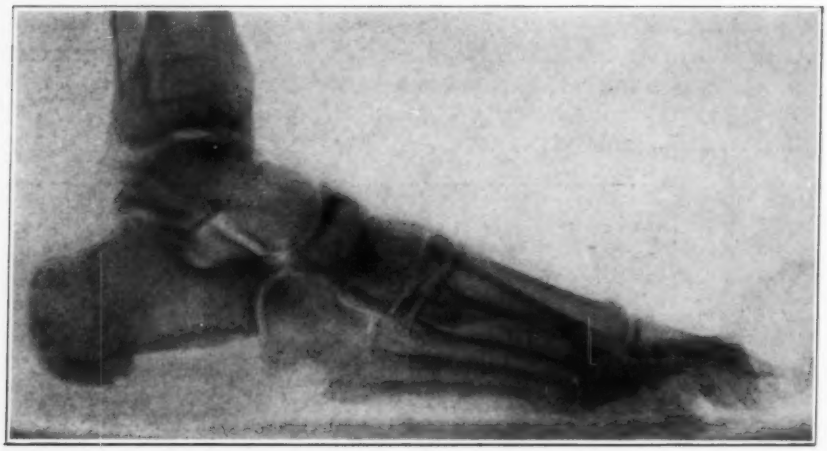

FIG. 10-F

Case 2. Lateral roentgenogram right foot five years after operation.

Case 3: M.D., aged fifteen years.

FIG. 11-A

Case 3. Anterior view, before operation.

FIG. 11-B

Case 3. Posterior view, before operation.

FIG. 11-C

Case 3. Anterior view, six years after operation.

FIG. 11-D

Case 3. Posterior view, six years after operation.

In this case there was so much outward torsion of the first metatarsal that an osteotomy of this bone was done. The distal part of the bone was rotated inward and the anterior end pitched downward in the setting in addition to the lengthening of the Achilles tendon and the stabilization of the scaphoid-cuneiform joint.

Following are roentgenograms in the case of an adult before and after operation, patient standing. The latter was made before the graft had lost its identity, and is exhibited in order to show the position of the graft as well as the architectural correction of the skeleton.

Case 4: Miss M.M., aged forty-seven years.

FIG. 12-A

Case 4. Lateral roentgenogram left foot before operation.

FIG. 12-B

Case 4. Lateral roentgenogram left foot after operation.

CONCLUSIONS

For the reasons stated, it is seen that feet like these cannot be corrected except by operation. From the photographic and roentgenographic demonstration, it is seen that they can be anatomically corrected by the above described operative plan if it is accurately carried out.

USE OF THE ANTERIOR SUPERIOR SPINE AND CREST OF ILIUM IN SURGERY OF THE HIP JOINT*

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ARTHRODESIS

The procedure known as arthrodesis is extensively used in the treatment of certain affections of the hip joint. Its development was at first slow, and many failures were noted. Nové-Josserand stated that arthrodesis was first used for old dislocations of the hip as early as 1885 by Heusner, Lampugnani and Albert. Dollinger, in 1890, began to use it for paralytic hips, and later Lagrange used it for pathological dislocations. Albee is generally credited in this country with having first used intra-articular arthrodesis; the operation was described by him in 1908 for use in cases of osteo-arthritis of the hip. It was used later for tuberculosis.

Little can be found to indicate satisfactory results from the older type of arthrodesis. The few end results studied are rather meager in detail, in spite of the fact that "the best result in tuberculosis of the hip is a stiff hip" was recognized as long as ten years ago. Rogers and Peabody, Spiers, and Farrell have reported small series of cases. Farrell stated frankly that the results were poor. Besides the use of arthrodesis in tuberculosis of the hip, where it is much more frequently indicated than in any other condition, it has some use in osteo-arthritis, in old pathological dislocations, and in certain cases of traumatic arthritis.

Other types of operation generally used have been described as extra-articular, para-articular and combined intra-articular and extra-articular. Few purely extra-articular types of operation are described. Para-articular procedures are generally regarded as opening the capsule of the joint, usually along its superior surface, whereas intra-articular arthrodesis indicates an operation which opens the acetabular cavity widely by dislocating the femoral head, or what may be left of it, and attempting to secure bony union between the surfaces of the joint. Two different points of view are: that any type of operation which demands opening of the capsule must be considered intra-articular; and that an operation whereby ankylosis between the femur and the ilium is produced by a bridge of bone extending from the trochanter and neck of the femur to the ilium without disturbing the actual surfaces of the joint, is essentially extra-articular arthrodesis. The risk entailed in opening the superior surface of the capsule is minimal. The rating of an operation should be based on the speed with which bony ankylosis is obtained along the operative

*Read before the American Orthopaedic Association, Memphis, Tennessee, April 18, 1931.

field and on the simplicity of the procedure. The arguments against intra-articular operations are all based on the risk of dissemination of tuberculosis. This risk is minimized in operations that expose only a small part of the tuberculous area. The procedure simplified to a minimum, which produces ankylosis in the minimum of time, is the ideal type of operation.

In the last ten years many operations of the so called extra-articular or para-articular type have been described and the results with these have been much more promising. The fact that many different operations have

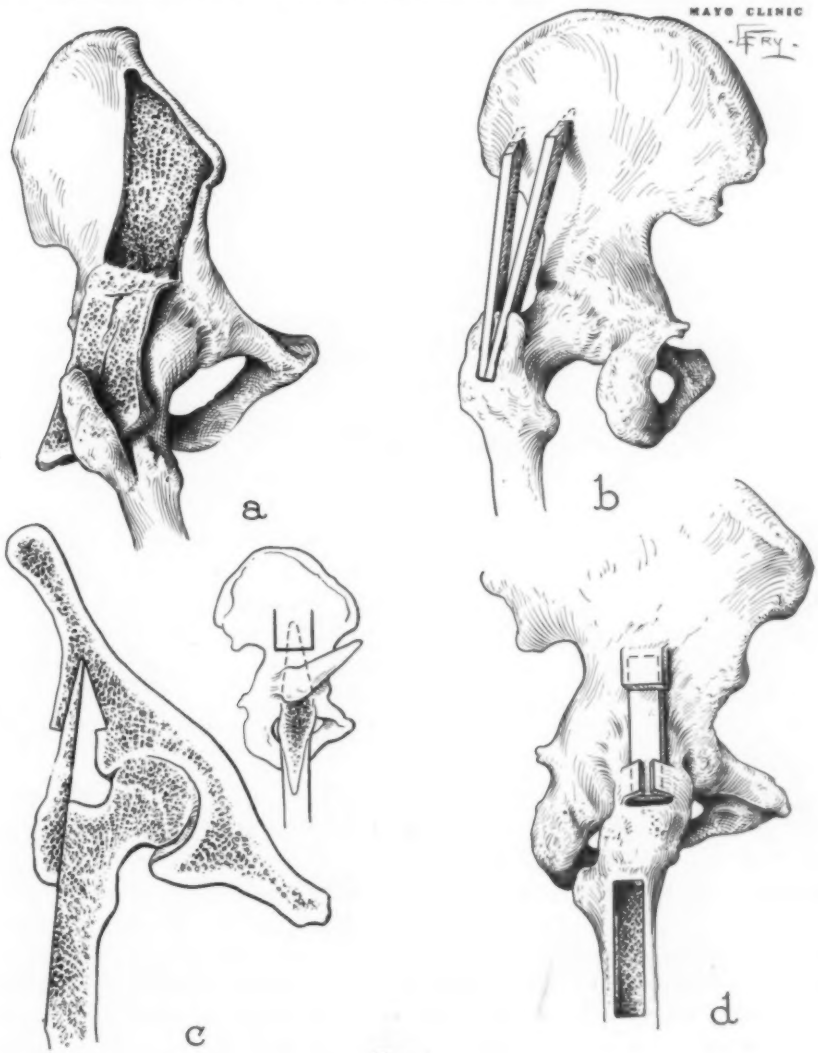

FIG. 1

Types of arthrodesis. *a*, Wilson, J. C., 1927; *b*, Albee, 1919; *c*, Hibbs*, 1926; *d*, Schumm, 1929.

*This illustration is taken from Albee's article[5]. The graft lies closer to the femoral neck in Hibbs' original illustration.

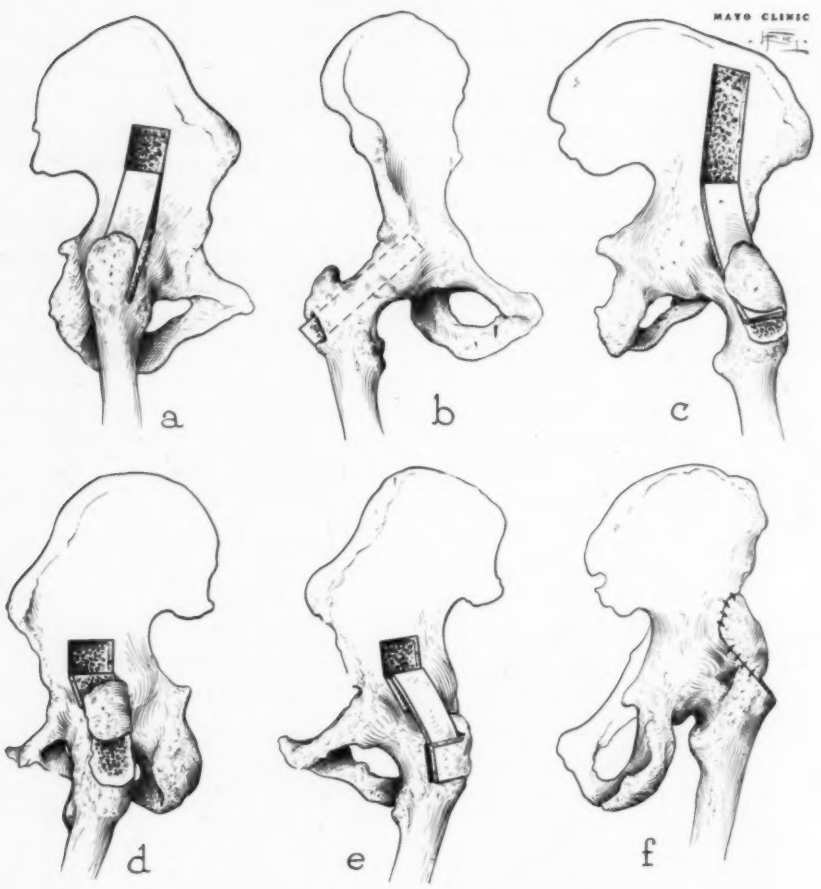

FIG. 2

Types of arthrodesis. *a*, Albee, 1929; *b*, Nové-Josserand, 1921; *c*, Sorrel, 1930; *d*, *e*, Mathieu, 1926; *f*, Hass, 1922.

been described probably indicates some dissatisfaction with the operations already suggested.

It is my purpose to review as briefly as possible previous methods for producing arthrodesis of the hip by the extra-articular or para-articular methods and to present, as a preliminary report, another type of operation which I have not found described in the literature. The series of cases is not large, but the results thus far seem favorable enough to warrant its further trial.

In reviewing the various types of operations I shall attempt to accord priority. I have arranged a series of illustrations of ten of the most representative operations (Figs. 1 and 2). Seven of the illustrations are from the original publications. Three were taken from publications by others but I believe show the essential features as outlined by the originators of the operations. Nové-Josserand stated that DeBeule first practised

extra-articular arthrodesis of the hip in 1907 by ankylosing the femur to the ischial tuberosity. Albee claimed to have first performed extra-articular arthrodesis in 1913, but I was not able to find any report of the operation by him until 1919. He has recently reviewed the subject, reporting uniformly successful results in thirty-one cases. Kappis made three reports on a similar type of operation, the last in 1924 when he summarized his results. Schmidt reported a similar type of operation worked out independently of Kappis. Leriche, Maragliano, and Allison used the same general type of procedure. In Allison's and Maragliano's operations, the lower end of the graft was buried into the upper end of the shaft of the femur proximal to the trochanter. Allison combined this with intra-articular arthrodesis, roughening the margins of the acetabulum and head in order to produce fusion at the margin of the joint. All of these operations are similar, in that they make use of a graft from the cortex of the tibia which bridges from the trochanter or upper end of the femoral shaft to the outer wall of the ilium. They represent a technical extra-articular type of operation.

Nové-Josserand[39] reported the use of a fibular graft running through the neck and head of the trochanter, to the upper portion of the acetabular cavity. He later reported fair results in seven cases[40]. A different procedure was reported by Maragliano in which a tibial graft was passed from the femoral shaft to the ischial tuberosity. He reported only one case in which this method was used.

Hass, in 1922, reported an operation for arthrodesis of the hip, in which he transplanted the trochanter with a portion of the femoral shaft upward to the line of the joint, suturing it to the neck of the femur and to the wall of the ilium. In one case in which operation had been performed a year previously the result was good. Hibbs, in 1926, reported a series of twenty cases in which he transplanted the trochanter to the neck and acetabulum with favorable results in all but three cases. Since then others have reported various types of extra-articular arthrodesis. Thus it appears that this type of operation is generally accepted in principle although the actual procedure varies greatly. Mathieu[34, 35] described two procedures. Sorrel[16] reported favorable results from the use of one of these procedures. He also reported on a mixed type of intra-articular and extra-articular arthrodesis[47]. Nové-Josserand, Rendu, and Bérard reported good results from the Mathieu operation in two cases. Calvé and Leriche both described operations in which the osteoperiosteal graft was used in a somewhat similar fashion to that of Mathieu. Báron, in 1921, reported on the use of an osteoperiosteal graft from the ilium to the trochanter a considerable time before its use was reported by others.

Key advocated the use of osteoperiosteal grafts, as did Campbell. Wilson, and Schumm described different procedures. The entire subject has been reviewed by Bristow who favored the Hibbs operation and by Bérard who naturally favored the French type of procedure.

No doubt in this review of the literature various reports on this procedure may have been overlooked, but it is obvious that the studies of end results are not sufficiently inclusive to be convincing. There are few really extensive series from which conclusions may be drawn. Albee's series of thirty-one cases, Hibbs' series of twenty cases, and Kidner's series of sixteen cases are the largest reported thus far. It is perhaps safe to say that none of these methods has had sufficient trial to have aroused its enthusiastic and widespread adoption. The procedure I am about to describe has been given sufficient trial to convince me that it is simple and effective in a small group of cases.

Operative procedure.—An incision is made, starting at a point about seven and five-tenths centimeters backward along the crest of the ilium from the anterior superior spine, running directly downward to a point about two and five-tenths centimeters below the tip of the trochanter, from which point it is gradually curved forward to a point about ten to fifteen centimeters below the anterior superior spine. The flap of skin is turned mesialward and upward, exposing the fascia lata, the crest of the ilium, and the trochanter. There are two particular advantages of this

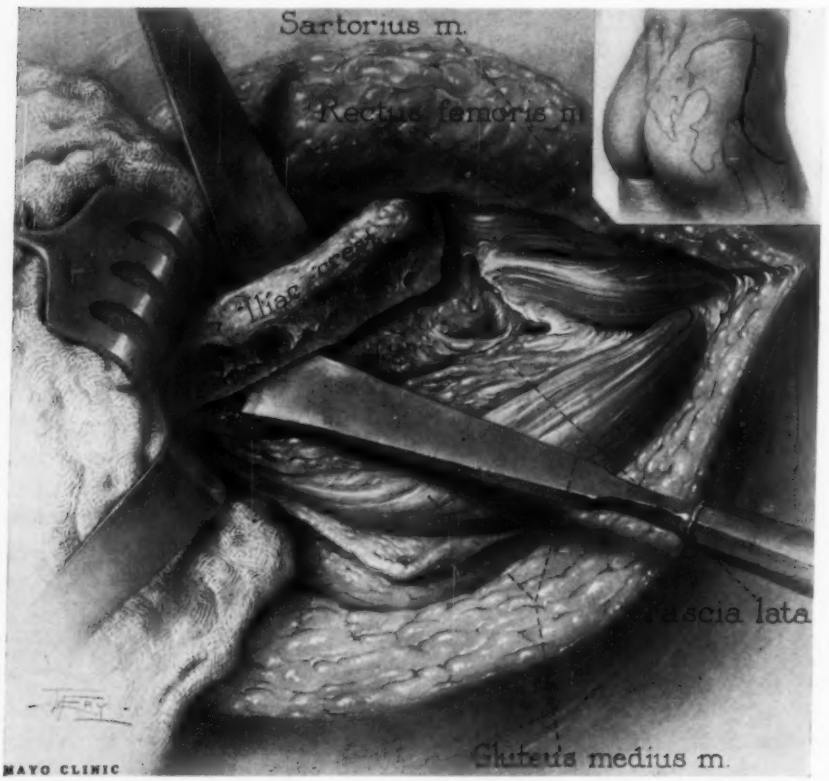

FIG. 3

Exposure of crest of ilium and removal of graft. Inset shows line of incision in skin.

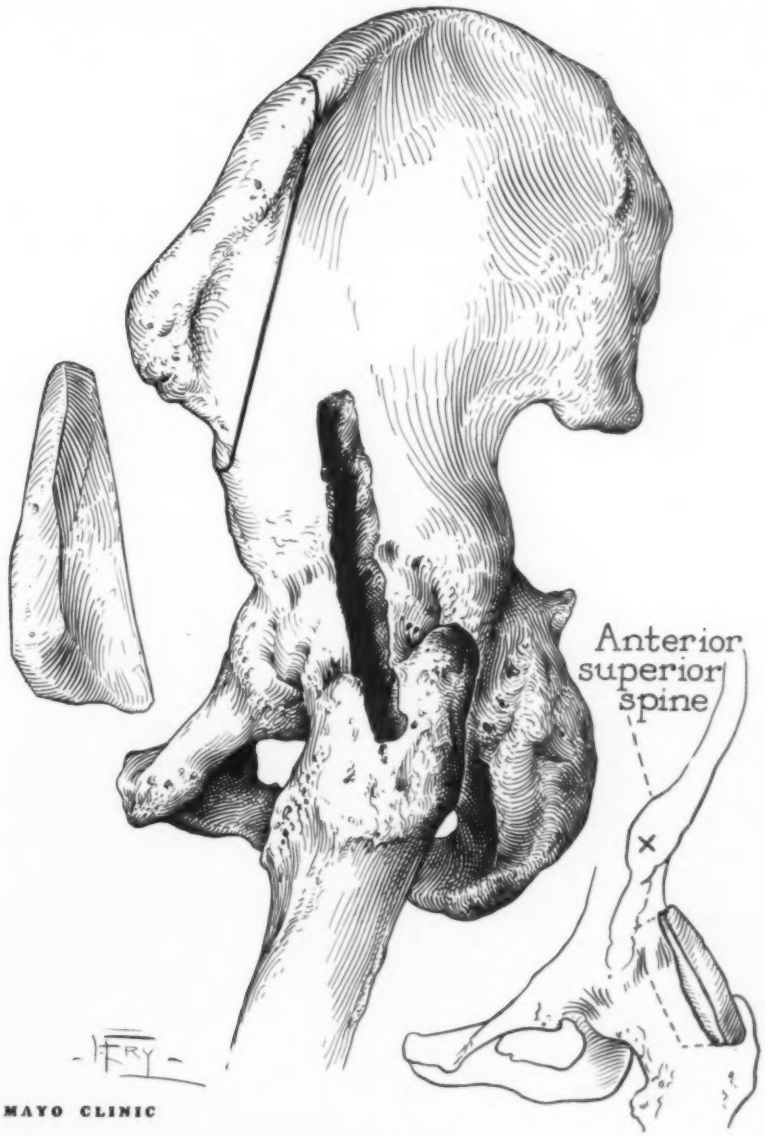

FIG. 4

Groove for graft running through trochanter, neck, head and ilium. Inset shows schematic position of graft impacted in position.

incision: it is made at a distance from the inguinal region, which may often harbor more infection than the remaining skin; and it allows dependent drainage in a recumbent position, and serum seldom collects under the flap of skin From this point onward the exposure is similar to that described by Smith-Petersen. A thin layer of the outer surface of the crest is cut away, together with the muscular and fascial attachments, in exposing the

ilium. Before extending the exposure to the head and neck, the graft should be removed. This is done by freeing the crest of the ilium of all muscle attachments from the anterior superior spine and for a distance of approximately seven and five-tenths centimeters backward from the anterior superior spine. The periosteum along the inner surface of the ilium is elevated over a corresponding distance. With a fairly broad osteotome the exposed portion of the crest, including the anterior superior spine, is then cut off (Fig. 3). The freshly cut edge of the ilium is covered with a hot salt pack and that entire upper area of the wound is blocked off from the remainder of the field by salt packs. The graft is carefully preserved for later use.

The exposure of the acetabulum, head, neck, and trochanter is then made by an incision the entire length of the capsule in the plane of the neck and trochanter. This brings the exposure down on the upper surface of the neck and head and the lateral surface of the ilium above the acetabulum. Separation of these soft parts from the bone is carried just far enough to make a channel the width of the crest of the ilium. With a gouge a groove is cut along the side of the ilium, the upper surface of the head, neck, and trochanter at the depth of this channel (Fig. 4). The bone chips thus loosened are not lifted out. The graft is then prepared by removing all periosteum from its surface and beveling it to an irregular edge. This edge is then placed in the groove and impacted into its position (Fig. 4). Usually

FIG. 5

Tuberculosis of hip of one year's duration in a boy aged fifteen years; preoperative roentgenogram.

it can be so firmly impacted as to seem solid. The soft parts are sutured over the graft. Care must be taken before implanting the graft to have the hip in the desired position for ankylosis and it must be so held until the plaster is applied. The wound is closed, bringing the attachments of the gluteal muscles to their original position and suturing them to the edge which was freed from the upper surface of the crest of the ilium.

A plaster spica cast is applied to the toes on the affected side and to the knee on the non-affected side. This cast is left on three months if possible; the first dressing is done in three weeks through a window. The second cast need only go to the ankle on the affected side. Thus far ankylosis has taken place so early that fixation over six to nine months has not seemed necessary (Figs. 5 and 6).

The advantages of using the crest of the ilium appear to be twofold; it is easily obtained in any exposure of the hip, and the cancellous bone of the iliac crest furnishes ideal bone for grafting purposes. The graft lies in position in close contact with the surface of the neck and the ilium. In many cases it seems made to fit accurately in this position. It acts as a "flying buttress" which is mechanically as strong a structural support as possibly can be made. The simplicity of the procedure makes for speed in operation and lessens the danger of shock. In all cases the postoperative reaction has been minimal. I am sure the use of the crest of the ilium for bone-grafting purposes is more widespread than reports in the literature would indicate.

FIG. 6

Same case as that shown in Fig. 5 four months after operation; ankylosis apparently solid.

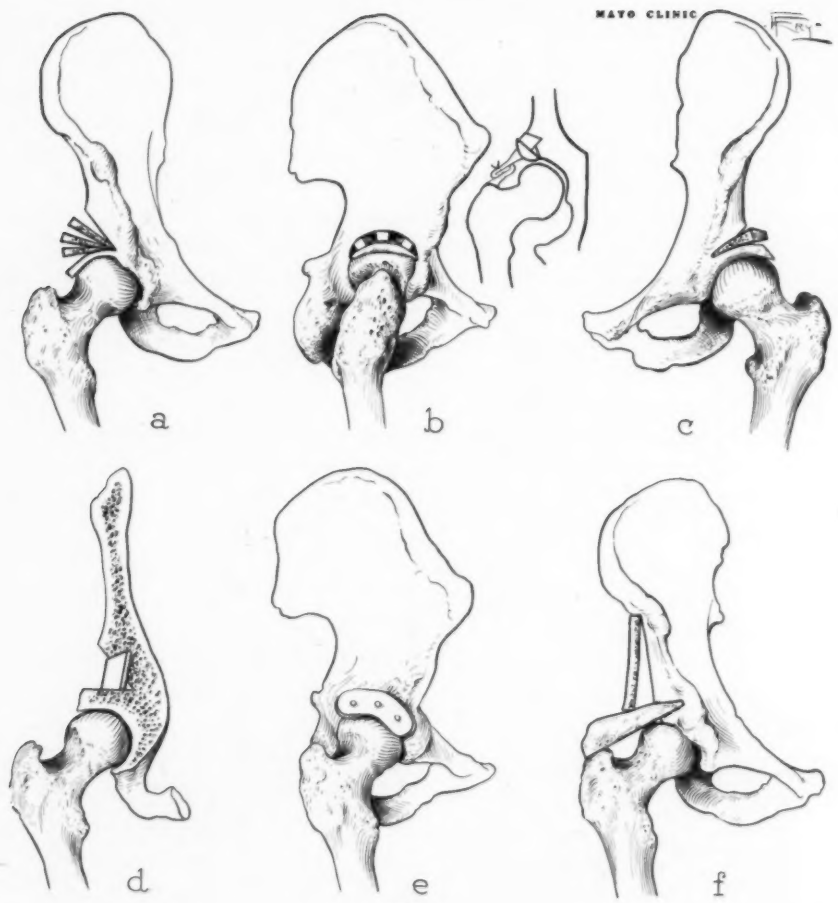

FIG. 7

Types of shelf operation: *a*, Lance, 1925; *b*, Albee, 1915; *c*, Dickson, 1924; *d*, Jones, 1920; *e*, Hey Groves, 1927; and *f*, Soutter, 1930.

SHELF OPERATION FOR CONGENITAL DISLOCATION OF HIP

It is my conviction that in most cases of old unreduced congenital dislocation, or in cases in which reduction may be accomplished but cannot be held, some type of shelving operation offers the best means of stabilizing the new acetabular cavity. The procedure has its shortcomings, but it is doubtful if they are more serious than those of other types of operation. I have found that it offers the best chance for functional improvement. The operation is not indicated for old congenital dislocations in which the head is carried well up behind the acetabulum and is riding on the posterior portion of the ilium, but for cases in which subluxation takes place from infantile paralysis, or from congenital dislocations of the hip in which the head rides just above, or above and anterior to, the acetabulum.

The shelf operation is not new. Scholder stated that König performed such an operation in 1891. Ferguson, in 1904, and Clarke, in 1909,

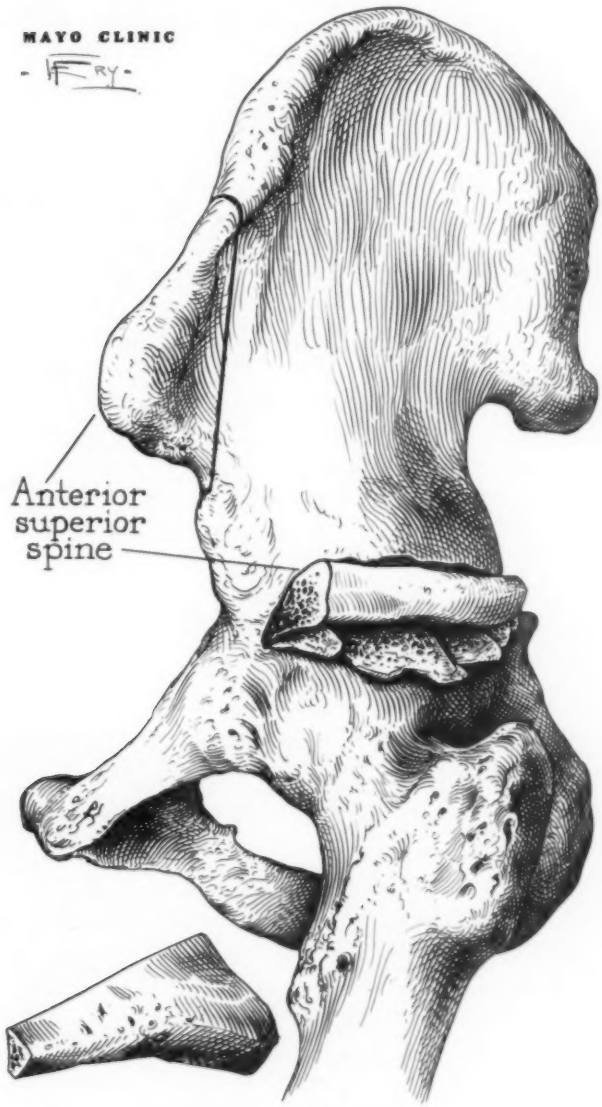

FIG. 8

Line of cut through anterior portion of iliac crest. The cut edge is beveled and driven into the groove above the new acetabulum.

performed a somewhat similar operation with the same end in view. Albee reported an operation which he called "bone-wedge graft remodelling operation" (Fig. 7). Previous to this time Delagénière repaired the margin of the acetabulum in a case of gunshot wound of the hip with an osteoperiosteal graft. Jones reported a case in which this type of operation was used. Fairbank reported an operation in which an upper lip was fashioned to

the acetabulum "in one case without opening the joint"; a graft was not used. Mauclaire, in 1922, reported the use of osteoperiosteal grafts in forming a shelf in a case of congenital dislocation of the hip. Hallopeau made a tunnel through the bone and periosteum over the acetabulum through which a piece of dead bone was inserted. Dickson, in 1924, reported five cases in which a wedge of bone from the iliac crest was used to hold the shelf in position. Lance reviewed the subject of shelf operations and reported a similar procedure, with the use of osteoperiosteal grafts to hold the shelf in position. Gill reported a similar procedure. Hey Groves reported four different operations. He stated that the "method in common vogue" is to transplant the anterior superior spine down to a position above the acetabulum and hold it in place with ivory pegs. His other procedures included the introduction of an ivory rim to the acetabulum and the formation of a shelf from the wall of the ilium, by converging flaps and a similar shelf held by ivory pegs. Spitzy reported a shelf operation in which the shelf was made by a massive graft from the ilium and the head was held in position by another graft driven into the acetabulum. Spitzy stated that the second graft later absorbed, and the head was held in position by the shelf. Soutter recently suggested fashioning a shelf out of a piece of bone taken from the anterior surface of the neck, trochanter, and shaft of the femur, and wedging it into the ilium above the head; the bone may be held in place by a piece of the outer table of the ilium.

FIG. 9

Painful bilateral congenital dislocation of the hips, which had never been treated; roentgenogram before operation (patient a woman aged twenty-one years).

The similarity of these various types of operations is obvious; the principle involved is the same in all. There are two points in regard to the application of this type of operation which might be emphasized: (1) the hips should be reduced or at least brought as far down as possible by heavy traction applied either several days before operation or at the time of operation, and (2) the shelf should cover as much as possible of the entire upper surface of the head, but should not extend far enough laterally to interfere with abduction. It is not necessary to have the shelf jut out over the trochanter if the head is present.

Operative procedure.—Exposure of the ilium and margin of the acetabulum are accomplished as described in the technique of arthrodesis. With the head pulled down as far as is possible on a traction table, chips of bone are turned down over the head with its capsule intact. These chips are cut with a slightly curved chisel in such a way as to have their heaviest portion or base as close to the head or new acetabular margin as possible and enough are laid down to have a fairly straight cut above the acetabulum. With the same care as described in the technique of arthrodesis, the anterior superior spine and anterior portion of the iliac crest are freed entirely of periosteum and muscular attachments. This portion of the ilium is then cut away, with the use of a chisel so held that the cut surface is beveled sharply downward (Fig. 8). The cut edge of this graft is then placed in the groove above the acetabulum and driven inward, the beveled

FIG. 10

Same case as that shown in Fig. 9; condition on discharge, showing new "shelf" on each side (roentgenogram taken in prone condition).

edge fitting snugly so that the entire shelf structure is held firmly in place (Fig. 8). The wound is closed. Traction straps having been previously applied to the leg, a cast is applied to the ankle, and traction is maintained. After eight weeks the traction is omitted and the patient is allowed to be up. Skeletal traction may be used if it seems indicated, in which case the cast should extend only to the knee. Walking with crutches may be commenced at the end of eight weeks and without crutches at the end of twelve weeks (Figs. 9 and 10).

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OPEN REDUCTION OF CONGENITAL DISLOCATION OF THE HIP*

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Certain weaknesses in the treatment of congenital dislocation of the hip in young children, by whatever method used, are generally admitted. The percentage of unsatisfactory results, either immediate or deferred, is too great. There is no unanimity of opinion as to method. Many methods, because they employ considerable degrees of force, produce trauma to the cartilage, bone, or muscle, which interferes with proper development of the joint. Recurrence of the dislocation after closed reduction is all too common. Limitation of motion after open reduction is distressing. The time involved is expensive and irritating to the child's parents, to the community, and to the surgeon. Efforts to overcome any or all of these weaknesses are worth while.

In 1920 Galloway of Winnipeg (*The Journal of Orthopaedic Surgery*, II, 390, January 1920), published his article on open reduction of the hip as a routine measure to replace closed reduction, even in very young children. He maintained that the trauma incident to forcible manipulative reduction was frequently responsible for bad results. He stated that open reduction through an anterior incision avoided much of this trauma and allowed accurate reduction and adaptation of the acetabulum to the head of the femur. He insisted that the so called "hour-glass" constriction of the capsule must be cut in order to obtain perfect reduction. He inferred that this constriction often formed an insurmountable obstacle to closed reduction.

Even before the publication of Galloway's paper we had felt, at the Children's Hospital of Michigan, that closed reduction was unsatisfactory and that open reduction offered a better surgical procedure. Encouraged by Galloway, we gradually adopted a routine procedure: First, a gentle attempt was made at closed reduction by any of the standard methods, best exemplified by that of Ridlon. If this was unsuccessful, a period of traction was employed and then a second gentle attempt was made. If this was not successful, open reduction was immediately done. No considerable force was ever allowed at the manipulative attempts. Gradually we learned to discard the period of traction, and to proceed immediately to open operation after the failure of the first attempt at closed reduction. In general, our open reductions were satisfactory; but because of ignorance of

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the mechanical problem, we often used too large incisions, and cut or tore too many muscle fibers and, as a result, had too many stiff hips.

In June 1930, during the course of an open operation on a seven-year-old child (Case 1), we realized for the first time that the medial layer of the elongated capsule was firmly adherent to the side of the ilium, across the false acetabulum, up to the level of the head of the femur. Downward traction on the leg made this adhesion tense, so that it acted as a suspensory ligament, preventing the head from descending. Before opening the capsule, we freed it from the side of the ilium by blunt dissection and found that the head could be pulled downward, by simple traction, for an inch or more. The capsule was then opened longitudinally, exposing the region of the true acetabulum. This brought into view the so called "hour-glass" constriction of the capsule, which proved to be only the stretched inferior portion of the capsule, acting as a diaphragm across the acetabulum (Fig. 1). Its upper edge was simply the fold made up of the reduplication of the lower portion of the capsule. This was cut as in Galloway's procedure. The well formed head was then easily skidded into the fairly satisfactory acetabulum, and the wound closed with no special attention to the two portions of the capsule. The hip was put up in a single plaster-of-Paris spica with only moderate abduction. The x-ray next day showed recurrence of the dislocation. Four weeks later a second open reduction was done and the hip put up in greater abduction. Seven days later an anterior displacement of the hip was found, and a manipulative reduction was done. Following this last procedure, the hip was left in the plaster for two months, when physiotherapy was started in a plaster shell. Walking was allowed in four months and the result is now satisfactory.

This case demonstrated several new features in congenital dislocation of the hip in young children: First, the upper layer of the elongated capsule was adherent to the side of the pelvis (Fig. 1)* and acted as a suspensory ligament to prevent the descent of the head. A search of the literature failed to reveal mention of this feature in articles dealing with the clinical aspect. There were two references to it in anatomical articles by H. A. T. Fairbanks in the *British Journal of Surgery* (XVII, 380, January 1930), and by Deutschländer (*Zeitschrift für Orthopädische Chirurgie* XX, 189, 1908) as quoted by Steindler in his *Textbook of Operative Orthopedics* (New York, D. Appleton and Company, 1925). Second, the so called "hour-glass" constriction is nothing more than the reduplication of the lower portion of the capsule. Third, in young children the capsule by its action as a suspensory ligament resists replacement much more than do the contracted muscles. Fourth, the reduplicated fold of the lower portion of the capsule (Fig. 2) acts as a gate across the mouth of the true acetabulum, which can be opened only by surgical incision. Fifth, if this gate is not opened, a cushion between the head and the acetabulum remains, which must predispose to redislocation, and which in successful closed reductions must take a long time to disappear.

*The author acknowledges with thanks the kindness of Dr. Daniel H. Levinthal of Chicago, who provided the three diagrams illustrating the operative procedure.

FIG. 1

Upper leaf *A* of capsule adherent to side of pelvis.

FIG. 2

A acting as suspensory ligament.
B folded across acetabulum.

FIG. 3

Upper fold *A* freed. Fold *B* closing off acetabulum.

With these facts in mind, we have endeavored to put them to use in a series of open reductions in children under eight years of age, and have developed the technique described in *The Journal of Bone and Joint Surgery* for January 1931 (XIII, 104).

This technique consists of a vertical incision, four to six inches long, beginning at the anterior superior spine. It parallels the outer border of the sartorius. Dissection between the sartorius and the tensor fasciae femoris exposes the rectus, which is retracted outward. The psoas is retracted inward and the capsule covering the dislocated head is exposed. In all the cases the capsule has been found thickened and firmly adherent to the side of the ilium, up to the level of the top of the dislocated head. This adhesion becomes tense when downward traction (Fig. 2) is applied to the leg and forms a sort of suspensory ligament which strongly resists downward motion of the head. It is separated downward to the level of its attachment to the top of the true acetabulum. Downward displacement of the head by traction on the leg is then easy (Fig. 3). The capsule is opened, exposing the region of the acetabulum, and the reduplicated sickle-shape fold of the lower portion of the capsule recognized (the so called "hour-glass" contraction). This is widely cut. If necessary the true acetabulum is then enlarged and deepened to fit the femoral head. If the upper border of the acetabulum is too shallow, it can be made deeper by inserting a gouge, from above, outside the joint in such a manner as to pry downward a little of the cartilage of the upper portion of the acetabulum, with the attached upper layer of the capsule. Reduction of the head is now usually easy, without any mechanical aids. If the steps of the operation, so far, have been carried out properly, the reduction is very stable. To reenforce it the upper leaf of the capsule is brought downward across the head and firmly sutured to the lower leaf at the lower border of the acetabulum. The wound is then closed, and the hips put up in a double plaster-of-Paris spica.

A series of fifteen cases have been operated upon since June 1930, including all cases between the ages of two years and eight years. In all these cases the anatomical features described have been found. In all, the resistance to reduction has been found to lie in the capsule and not in the muscles. All cases now show solid reduction. One patient unfortunately died twenty-four hours after operation from acute acidosis, a diagnosis made by the medical staff of the hospital. This child was operated on, through error, the day after admission to the hospital with only the ordinary anti-acid preparation. After death, it was found that the child had been eating little or nothing at home for the previous week. As it is the only post-operative death from open operation on the hip in five years at the Children's Hospital, it seems unfair to use it as an argument against open reduction of the hip.

As the operation and after-care have developed, certain facts have become clear. The long Smith-Petersen incision is not necessary. A straight incision between the sartorius and rectus gives ample exposure. Occasionally it is necessary to remove the rectus from its pelvic attachment. The psoas does not interfere with reduction. The adductors are occasionally so short as to make it difficult to lift the head over the brim of the acetabulum. The muscles do not prevent the downward course of the head. The exposure, after freeing the adhesions of the capsule to the side of the pelvis, before opening the capsule, makes it easy to reconstruct the acetabulum. We have learned that the downward dissection of the capsule to its attachment to the upper border of the true acetabulum serves to mark this border clearly. If this dissection is carried a little further, extra-articularly, into the cartilage of the upper border of the acetabulum, a sort of shelf is formed, under which the head may be lodged firmly. The downward dissected capsule gives us a strong band of tissue which, when sutured across the replaced head to the lower leaf of the capsule at its attachment to the lower border of the acetabulum, provides a solid investment which holds the head in place so firmly that there is no tendency to redislocation during the application of the plaster.

The reduction by this method has been found to be so stable that we have progressively shortened the time of fixation in plaster. Our routine now is to bivalve the plaster at the end of three weeks, when physiotherapy is started with passive motion. Walking has been allowed at eight weeks without harm, but we feel that further experience will be necessary before this becomes routine. Probably twelve weeks before walking is a safer time.

The observations in this paper do not apply to children over eight years of age, because it has been found in them that the capsule has freed itself from the side of the pelvis, and the muscles have actually shortened. These older children, therefore, present an entirely different problem, to solve which much more complicated procedures are necessary.

We are convinced that open reduction done by the method described, which is based on anatomical facts new to us, meets several of the objections

FIG. 4

Case 1. K. B. Before operation.

FIG. 5

Case 1. K. B. After operation.

to the usual forms of treatment mentioned in the first paragraph. It is simple and involves a minimum of trauma. It is safe. There is no tendency to redislocation. Some stiffness of the joint follows it, if reshaping of the acetabulum has been necessary. This stiffness gradually disappears. In many cases it avoids the necessity for shelf operations. Last and most important of the advantages of this method is the fact that it cuts the period of convalescence at least in half.

The protocols of six of the cases are attached, because these patients were operated upon sufficiently long ago to provide a fair estimate of the probable results.

CASE REPORTS

CASE 1. Katherine F. B., aged seven years. First seen June 1930.

Physical examination. Severe limp. Head of left femur very high and posterior. Two inches shortening. X-ray showed head in large false acetabulum and a fairly good true acetabulum.

Open operation June 13, 1930, decided on because manipulation looked unpromising in view of the size of the girl and the muscular development. Open operation through modified Smith-Petersen incision. The capsule was found densely adherent to the ilium to the level of the top of the femoral head and enclosing it firmly. This adhesion was separated with a gouge. It was then found that simple traction brought the head down to a point near the level of the true acetabulum. The capsule was opened and a dense reduplication of the lower portion of the capsule was found to block the opening of the true acetabulum completely. This was freely cut. With a skid the well formed head was slipped into the fairly competent acetabulum where it seemed to be stable. No special attempt was made to close the capsule, but the muscles and skin were closed in layers. A single plaster spica was applied in slight abduction. Recurrence of the dislocation was found next day by x-ray. On July 10, 1930, a second open reduction was done through the old incision. Seven days later anterior displacement was overcome by manipulation. Plaster left on two months, when physiotherapy was started. Walking was allowed at six months.

Result March 31, 1931. Motion one-half normal. Function good with slight limp. X-ray shows head slightly high but both the head and the acetabulum are developing well.

CASE 2. Olga F. N., aged seven years. First seen May 1930.

Physical examination showed marked upward and backward dislocation of left hip with severe limp. X-ray showed deep false acetabulum, fair head, and true acetabulum One and one-half inches shortening. Open operation advised because of age of child and amount of displacement.

Operation June 27, 1930. Smith-Petersen incision. Capsule found firmly adherent to side of ilium up to level of top of false acetabulum. This adhesion freed with gouge, which allowed the head to descend one inch by simple traction. Capsule opened and good acetabulum competent to receive the good head found. Reduction easily accomplished with skid. Upper free leaf of capsule sutured closely over head to inferior leaf of capsule. Wound closed, hip retaining itself in place meanwhile. Double plaster-of-Paris spica applied with leg in moderate abduction. Reduction was maintained. Plaster was split and physiotherapy begun in four weeks. X-rays showed that the epiphysis remained persistently small and fear of injuring it caused postponement of walking for five months.

Result. March 31, 1931. Motion one-half normal. Function good. Position perfect with improved growth of head.

FIG. 6

Case 2. O. N. Before operation.

FIG. 7

Case 2. O. N. After operation.

CASE 3. Joan E., female, twenty months old. First seen June 1930.

Physical examination showed marked limp and left hip dislocated upward and backward. Child had been walking for six months. There was one and one-half inches of shortening and x-ray showed a very flat acetabulum with antiversion of the femoral neck. The patient's family agreed to open reduction in the hope that it would allow a shorter period of fixation and a more positive result than closed manipulation could do.

Operation July 1, 1930, was done through a vertical incision outside the sartorius and inside the rectus. It was not necessary to cut across any muscles or to remove any of them from the side of the ilium. The capsule of the hip joint was found firmly adherent by its upper internal layer to the side of the pelvis to a level as high as the head of the femur. By blunt dissection from above downward, the adhesions were freed. It was then found that simple manual traction on the leg brought the femoral head down to the level of the true acetabulum. The capsule was then opened in its long axis. This exposed a fold of the capsule crescentic in shape, evidently formed by the folding on itself of the lower leaf of the capsule. This was cut as in Galloway's procedure. The true acetabulum was then seen to be of good contour and size and sufficiently deep to allow of reception of the femoral head. Its boundaries were of course cartilaginous. This explained the x-ray appearance of a flat acetabulum. The head was then placed in the acetabulum with the fingers and with no aid from skid. The capsule was then closed with chromic catgut; the muscles and skin with plain catgut. It was unnecessary to use any precautions against redislocation during the application of the plaster spica because the hip was so stable. The hip was kept in plaster for five weeks when physiotherapy in bed was started. Walking was allowed at eight weeks.

Result March 31, 1931. Motion of hip within a few degrees of normal but with slight click during full flexion with internal rotation. Function normal though with a slight limp. X-ray shows acetabulum still shallow at top, femoral head slightly high, but developing well and apparently stable.

CASE 4. Ruth F. R., aged six and one-half years. First seen July 15, 1930.

Physical examination showed dislocation of left hip with some limp and two inches shortening. X-ray showed shallow false and true acetabula.

Open operation July 21, 1930. Smith-Petersen incision with very short upper arm to inner side of rectus. Capsule was found tightly enclosing head and densely adherent to side of ilium so that head could be raised or lowered only a small fraction of an inch. Capsule was separated from side of ilium with osteotome. This immediately allowed the head to be brought down one and one-half inches by simple traction. Capsule was then split. Reduplication of lower layer was found to block entrance of true acetabulum completely. This was split wide open. The upper border of the true acetabulum was seen to be shallow. It was then realized that the point of attachment of the upper leaf of the capsule to the side of the pelvis really determined the upper border of the acetabulum. Therefore, with an osteotome, outside the joint, between the ilium and capsule, a subcartilaginous ledge was pried gently outward, making the upper border of the acetabulum much more abrupt. It was necessary to enlarge the acetabulum slightly with a curet. The head was then easily and gently lowered into place. The importance of the capsular roof was then realized for the first time. Therefore, the upper portion of the capsule, which had been dissected downward from the ilium, was carried far downward over the replaced head and firmly sutured to the lower layer of the capsule at the lower border of the acetabulum. This made the hip so stable that it could be manipulated through one-half its normal range without redislocation and needed no support during the application of the double plaster spica. No redislocation occurred. Therefore, at the end of five weeks the cast was split and physiotherapy begun. Walking was allowed at eleven weeks.

Result March 31, 1931. Motion: four-fifths normal. Function: slight limp with tendency to roll, apparently because of persistent muscle weakness. X-ray: head somewhat high, but stable and developing well.

FIG. 8
Case 3. J. E. Before operation.

FIG. 9
Case 3. J. E. After operation.

FIG. 10
Case 4. R. R. Before operation.

FIG. 11
Case 4. R. R. After operation.

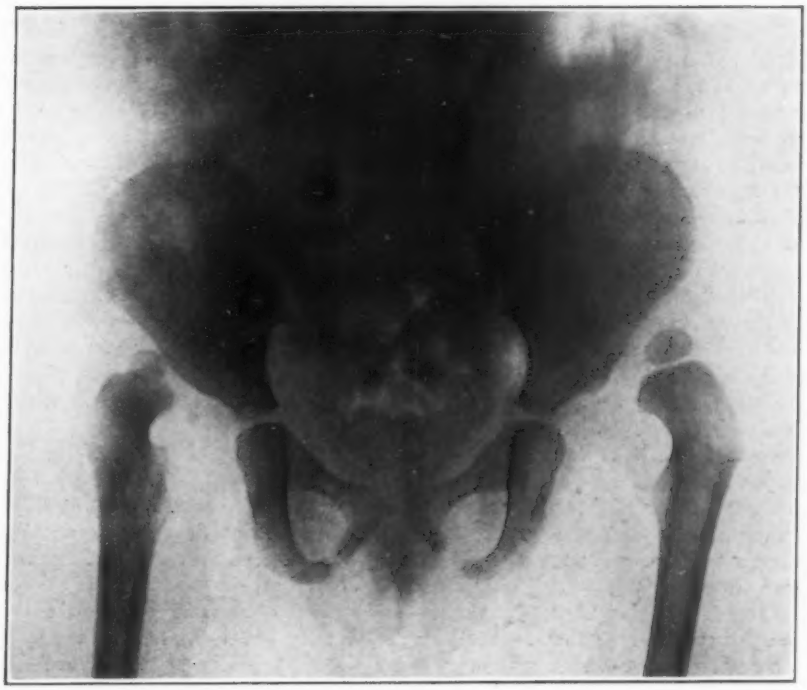

FIG. 12
Case 6. J. B. Before operation.

FIG. 13
Case 6. J. B. After operation.

CASE 5. Geraldine H., female, aged two years. First seen in 1928, for dislocation of left hip. Treatment refused till October 16, 1930, when open operation was done at four years of age. Vertical incision, inside rectus, outside sartorius. It was not necessary to cut rectus. Usual adherent and thickened capsule freed, allowing head to descend to level of true acetabulum. Lower reduplication of capsule cut, allowing approach to acetabulum which had to be somewhat enlarged. Reduction easy without skid, except that adductors were so short that there was some difficulty in lifting head over brim of acetabulum, but none in getting it down to the necessary level. After suture of the upper portion of the capsule to the lower, the hip was so stable that three-fourths normal motions could be carried out without dislocation. Put up in plaster at only twenty degrees' abduction and thirty degrees' flexion. This proved to be too slight, with result that the head slipped somewhat outward and upward sometime in the next month. It was replaced by manipulation on the first of December 1930, and again put up in greater abduction. No further displacement. Plaster removed December 27, 1930, four weeks later, as test. Physiotherapy started. No further dislocation. Walking started March 26, 1931.

Result March 31, 1931. Motion two-thirds normal. Function good. X-ray shows good position.

CASE 6. June F. B., aged two and a half years. First seen October 23, 1930.

Physical examination revealed double congenital dislocation with typical gait. X-ray showed backward and upward dislocation on both sides with a better acetabulum on right side.

Operation October 23, 1930. Closed manipulation of right hip easily reduced the dislocation and the reduction was fairly stable, but there was a sensation as though there was a cushion between the acetabulum and the head. The left hip was then reduced easily by closed manipulation, but the sensation of insecurity was very marked. Therefore, the left hip was immediately opened between the sartorius and the rectus. The usual adhesion of the capsule to the side of the pelvis was found and freed. This adhesion acted as a suspensory ligament to hold the head in its dislocated position. However, the resistance of this structure was not very great because of the patient's youth. Therefore, reduction by closed manipulation had been comparatively easy. On opening the capsule, the reduplicated lower portion of the capsule was found to form the usual diaphragm across the acetabulum. Normal reduction with the parts in plain view explained the insecurity of the closed reduction. The reduplication formed a cushion between the head and the acetabulum. This was, therefore, widely cut and a firm reduction easily obtained, which was stable after the usual suture of the capsule through a wide range of motion. Plaster was removed on November 17, 1930. Manipulation showed that the left or operated hip was very stable, but its motion was limited to about twenty degrees in all directions. This was apparently due to scar tissue. The right hip had much freer motion, but was unstable. Therefore, a single spica was applied to the right hip. Physiotherapy was started on the left. The cast was removed from the right hip in three months. Walking begun at four months.

Result, March 31, 1931. Normal motion on both sides. In the left there is a slight click on abduction. Function excellent. X-ray shows left hip slightly high but stable.

A NEW DEPARTURE IN THE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP*

BY ARTHUR KRIDA, M.D., F.A.C.S., NEW YORK, N. Y.

The method of treatment here described is a manipulative procedure throughout, contemplates a time period of six months, and is applicable to children up to three years of age.

The point of departure from previously described treatments consists of the recognition of the importance of "anteversion of the neck of the femur" or, as I prefer to call it, anterior distortion of the upper end of the femur, as a frequent cause of failure in the past; of the diagnosis of this structural defect early in the course of treatment, and of its correction in the course of the treatment of the dislocation itself.

The literature relating to the question is reviewed in two previous papers[1,2]. It is generally agreed that dislocations in this age group can be reduced by manipulation with comparative ease and with a minimum of trauma. This is true because secondary changes in the soft parts structures (which militate against a consistently satisfactory result in later age groups) have developed to only a slight degree. It seems to be also rather generally agreed that a very common cause of redislocation with accepted methods of treatment is the above mentioned anterior distortion of the upper end of the femur.

Muscular adaptability in early childhood is very great, as all know who have to do with locomotor disabilities which arise at that age. The bony structure is likewise adaptable, but much less so than is the muscular and ligamentous structure. The adaptations of soft parts structure, which nature is asked to make in order to secure stability in a reduced congenital dislocation of the hip, are sufficiently great. The added demand that nature reconstitute a denser tissue—that is, bone—frequently results in the failure of the whole enterprise.

The principles, therefore, upon which this departure from the usual treatment rests are these:

1. That infantile soft parts structures are practically always sufficiently adaptable to assure satisfactory development and stability in a reduced congenital dislocation of the hip.

2. That infantile bony structure is frequently insufficiently adaptable to assure a sufficiently rapid correction of the structural twist of the femur before redislocation may take place.

The requirements of the first of these principles are fulfilled by the reduction of the dislocation, and by fixation in an approximately physiological attitude; of the second, by artificial correction of the structural twist by fracture of the femur and suitable outward rotation of the distal fragment.

*Presented at the Annual Meeting of the American Orthopaedic Association, Memphis, Tennessee, April 16, 1931.

(a) The adductor contracture is corrected by stretching and by massage of the adductor origins. The dislocation is then reduced manually. A plaster-of-Paris spica is applied in the ninety-ninety degree attitude (Lorenz), and this attitude is maintained for two weeks.

(b) Two weeks after reduction the patient is anaesthetized. The conformation of the hip may then be evaluated by palpation. If the head of the femur presents itself superficially in the groin, it is not in contact with the acetabulum. If upon lessening the abduction to thirty degrees, it becomes still more prominent or displaces a little lateral to the line of the femoral artery, or if, under these conditions, even slight outward rotation of the extremity displaces the head laterally, it is assumed that a degree of anterior distortion of the upper end of the femur exists which, if not corrected, is inconsistent with ultimate security of the hip under consideration. The extremity is then accordingly rotated inward to a degree sufficient to place the head deeply in contact with the acetabulum, and a closely fitting spica is applied in the attitude of internal rotation, twenty-five to thirty degrees' abduction, and slight flexion at the hip and knee. These relations at the hip joint are maintained until the end of treatment.

FIG. 1

A case illustrating what is commonly found at open operation,—a degree of anterior distortion of the upper end of the femur which requires extreme internal rotation of the extremity in order to place the head into the acetabulum.

FIG. 2

Typical anterior distortion in a patient two years of age, showing the attitude utilized to place the head of the femur in proper relation to the acetabulum.

FIG. 3

X-ray after reduction. The Lorenz "90°-90°" attitude is maintained for two weeks only.

(c) Three months later the internal rotation of the extremity (which is the expression of the anterior distortion of that bone) is corrected by manually fracturing the femur in the supracondylar region (manual osteoclasis). After the bone is fractured, one hand grasps the head and neck of the femur and maintains thereby its relation to the acetabulum. The other hand grasps the distal fragment of the fracture and rotates that fragment outward to a degree fully to correct the internal rotation. A spica is applied

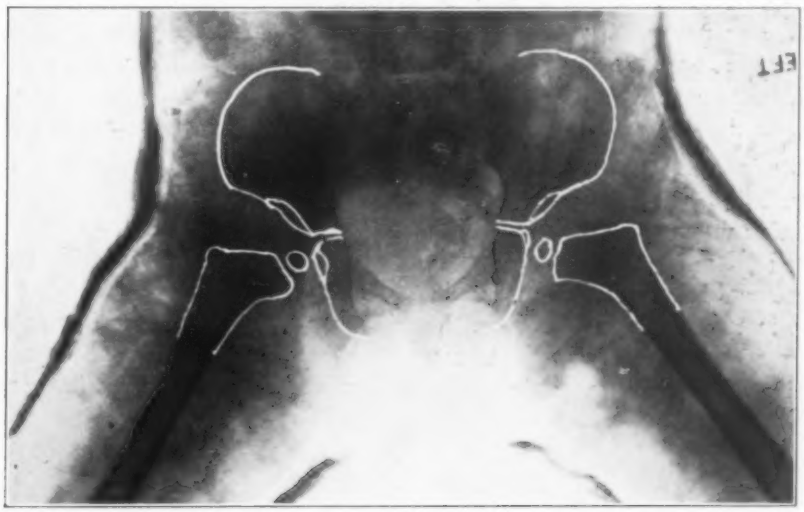

FIG. 4

X-ray through the second plaster. The extremities are rotated inward, but the hip joint relations are approximately physiological.

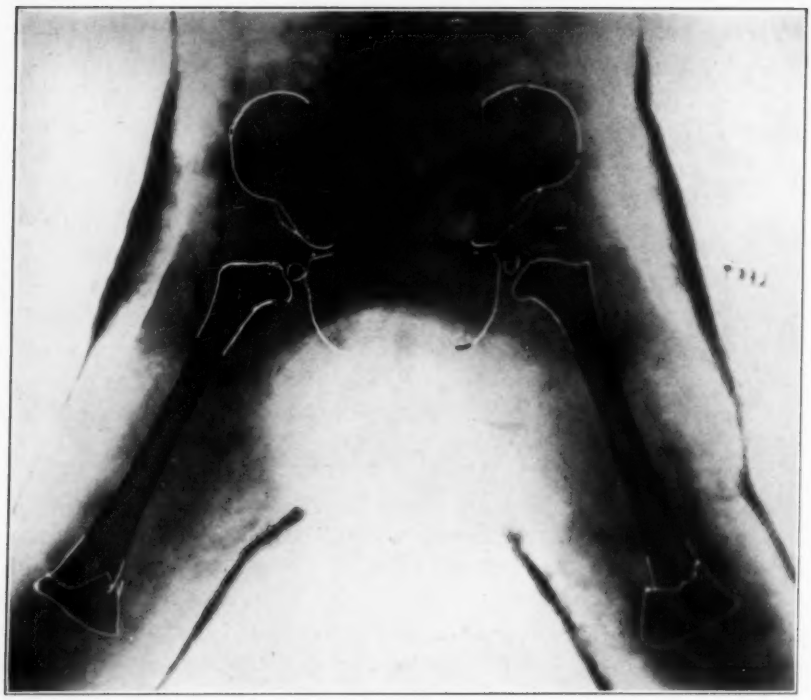

FIG. 5

The femora have been fractured manually and the inward rotation has been corrected by rotating the lower fragment outward, without having changed the hip joint relationships.

for two months, at the end of which time fixation dressings are discontinued.

(d) In those cases in which at the second sitting no anterior distortion was determined, the spica is applied at twenty-five to thirty degrees' abduction, slight flexion at the hip and knee, and with the extremity in the neutral attitude with regard to rotation. This spica remains applied for five months (unless required to be renewed by reason of wear and tear), and fixation dressings are then discontinued.

(e) In unilateral cases, after the final spica is removed, no specific after-treatment is necessary. Bilateral cases, on the contrary, are put to bed for one month, during which time they receive massage and exercises in the swimming pool. They must be carefully observed to the end that the restoration of mobility proceeds symmetrically, since the undue persistence of abduction in one hip will lead to hyperadduction, and consequent weakness in the other.

END RESULTS

The cases upon which this paper is based were all in patients under three years of age when treatment was begun. They include all the cases in which treatment was completed, arising in the out-patient department of

the First Surgical Division of the Hospital for the Ruptured and Crippled and a few private patients, from January 1926 to January 1930; also three cases from Bellevue Hospital during the latter part of that period. A minimum period of six months after the removal of plaster was allowed in the statistical summary; except in isolated instances, observation over considerably longer periods was possible.

A successful result was considered to be one in which the hip remained in place, with stability and a free range of motion. Minor anatomical imperfections as displayed in the x-ray (which, it may be stated, occasionally occurred), were not considered to vitiate a successful result.

BILATERAL CASES

Number	Hips	Anterior Distortion	Successful	Per cent.
16	32	22	29	90

UNILATERAL CASES

	21	18	19	90

Total number of hips, 53. Total number of cases with anterior distortion, in which osteoclasis was done, 40 or seventy-five per cent.

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LOCAL AND REGIONAL ANAESTHESIA IN ORTHOPAEDIC SURGERY

BY ALBERTO INCLAN, M.D., HAVANA, CUBA

The necessity of selecting the best method of anaesthesia in our operative procedures is universally recognized. Each case implies an operative risk, and this risk is greatly influenced by the method of anaesthesia selected. There is no standard method to be used in each type of case, for each has its indications, and the choice therefore must be made by the surgeon.

It is surprising to find that regional anaesthesia is seldom used in orthopaedic surgery, although this method is quite old, due to the work of Conway, Reclus, Quenu, Braun, and others. We believe that there is a great deal to be expected from its use, and that it is worthy of trial in bone surgery: shock is minimized; details of technique are not sacrificed for operating speed, as there is one hour and a half or two hours at least of complete anaesthesia without added risk to the patient; x-ray control is very easily obtained; application of casts and splints is simplified; pulmonary and acetonaemic complications are practically abolished; no special preparation is needed, except with very nervous patients when one centigram of morphin is prescribed before the operation; finally, food is allowed three hours before the anaesthesia and fluids are given during or immediately after the operation.

Should the surgeon be the anaesthetist? Although we think that the surgeon should be perfectly familiar with the method and know exactly its limitations, we believe that the surgeon himself should not conduct the anaesthesia. A specially trained anaesthetist is advisable and, with this precaution, many failures due to poor technique can be avoided. As Labat states: "It is not sufficient to have been present at a few demonstrations with regional anaesthesia for any man to give it successfully".

With the exception of local intrafractural infiltration employed following Böhler's suggestion in very recent fractures for their immediate reduction and fixation, we have always obtained the cooperation of our colleagues, Dr. J. Iglesias and Dr. Martinez Curbelo, both specially trained in regional anaesthesia.

During the last two years 197 cases have been operated upon with the use of local or regional anaesthesia, not including operations performed under spinal anaesthesia, although this technique is used in a large number of operations on the lower extremities. For that reason, regional anaesthesia has been employed in 158 cases in operations on the head and upper extremities, and in only thirty-nine cases on the lower extremities.

The accompanying tables illustrate the cases in which regional and local infiltration have been employed.

TABLE I

HEAD AND UPPER EXTREMITIES

Diagnosis	*Operation*	*Type of Anaesthesia*	*Amount of Novocain in Grams*	*Cases*
Fracture of zygomatic arch.	Elevation of depressed fragment.	Conductive supramaxillary nerve.	0.20	1
Osteomyelitis of supramaxillary bone.	Curettage and drainage.	Blocking of infra-orbital and palatine nerves.	0.30	2
Osteomyelitis of inframaxillary bone.	Curettage and drainage.	Conductive inframaxillary nerve.	0.20	4
Fracture of clavicle, humerus, or of radius and ulna.	Emergency reduction.	Intrafractural infiltration.	0.20 to 0.30	26
Shoulder dislocation.	Reduction.	Blocking of brachial plexus.	0.60	2
Fracture or dislocation of anatomical neck of humerus.	Excision of the humeral head.	Blocking of brachial plexus and axillary ring.	0.90	3
Fracture of surgical neck of humerus.	Suturing with kangaroo tendon.	Blocking of brachial plexus and axillary ring.	0.90	4
Fracture of diaphysis of humerus.	Closed reduction.	Blocking of brachial plexus.	0.60	6
Fracture of diaphysis of humerus.	Bone suture.	Blocking of brachial plexus and axillary ring.	0.90	4
Osteomyelitis of humerus.	Orr's treatment.	Blocking of brachial plexus and axillary ring.	0.90	3
Osteitis fibrosa of humerus.	Resection and bone graft.	Blocking of brachial plexus and axillary ring; regional infiltration of tibia.	1.30	1
Non-union of humerus.	Bone graft repair.	Blocking of brachial plexus and axillary ring.	0.60	3
Fractures of lower end of humerus.	Open reduction.	Blocking of brachial plexus.	0.60	4
Tuberculous arthritis of elbow.	Resection.	Blocking of brachial plexus.	0.60	1
Fracture of head of radius.	Resection of head.	Blocking of brachial plexus.	0.60	4
Fracture of radius.	Manual reduction.	Blocking of brachial plexus.	0.60	10
Fracture of radius.	Open reduction.	Blocking of brachial plexus.	0.60	10
Colles' fracture.	Reduction.	Blocking of brachial plexus.	0.60	5
Fracture of olecranon process	Suture.	Blocking of brachial plexus.	0.60	4
Old dislocation of elbow.	Open reduction.	Blocking of brachial plexus.	0.60	1
Fracture of ulna.	Reduction.	Blocking of brachial plexus.	0.60	6
Fracture of ulna.	Open reduction and suture.	Blocking of brachial plexus.	0.60	10
Fracture of radius and ulna.	Closed reduction.	Blocking of brachial plexus.	0.60	9
Fracture of radius and ulna.	Open reduction and osteosynthesis.	Blocking of brachial plexus.	0.60	14
Non-union of radius and ulna.	Bone graft operation.	Blocking of brachial plexus, sciatic nerve, and knee ring.	1.20	2
Old semilunar luxation.	Resection.	Blocking of brachial plexus.	0.60	2
Post-fracture deformity of forearm.	Osteotomy of radius and ulna.	Blocking of brachial plexus.	0.60	1
Finger dislocation.	Reduction.	Blocking of ulnar nerve and regional infiltration.	0.30	5
Gangrene, actinomycosis, osteomyelitis.	Amputation of finger, hand, or arm.	Blocking of brachial plexus.	0.60	11
			Total	158

In surgery of the upper extremities, we have used blocking of the brachial plexus in 120 cases, using this type of anaesthesia in preference to any other. Only in children under ten years of age, or in certain types of nervous patients who refuse to be operated upon with regional anaesthesia, do we use general anaesthesia: nitrous oxid, ethylene and ether. Labat states that he has had no experience with the use of brachial-plexus block in children. Twenty-five of our patients were children between ten and fourteen years of age. From five to ten minutes after the injection, there is complete anaesthesia. Occasionally the patient, aware of the operation, complains of pain, but a trial, after diverting his attention from the operative act, is sufficient to ascertain the truth. In but one case has there been a complication: pneumothorax, produced by puncture of the apical pleura, which disappeared without great discomfort to the patient. The technique actually used entirely avoids the possibility of this complication. In one case paravertebral lumbar and sacral anaesthesia was incomplete, due to the fact that the second sacral nerve was not blocked.

In twenty-five per cent. of the cases, we have observed a tendency towards fainting, nausea, cold sweating, and tachycardia. Sometimes, in emotional or nervous patients, these symptoms appear before the novocain is injected. Again such patients express an intolerance to novocain. In all cases, caffein, given hypodermically, is sufficient to eliminate these symptoms.

In only one case of the complete series have we registered great shock, which was treated successfully with blood transfusion. This case was operated upon at a great surgical risk, the patient being septicaemic following an acute infection developed in a comminuted fracture of the femur, surgically treated previously in a country hospital. Paravertebral and sacral anaesthesia was used in this case; the operation lasted two hours. We are convinced that with any type of general anaesthesia this case would have been fatal.

Neuritis, temporary paralysis, puncture of subclavial artery are mentioned as possible complications of brachial-plexus block, yet so far there has been none in this series.

The time of anaesthesia by either nerve block or field block is sufficiently long for any orthopaedic operation. From one hour and a half to two hours is considered the average time for nerve-block anaesthesia. In operations of long duration — like arthroplasty, reconstruction of the hip, osteoplastic fusion of joints — this method is recommended as the ideal one, particularly if one takes into consideration the additional time needed for the appliance of postoperative immobilization.

In patients with low blood pressure, this type of anaesthesia is preferable and is of great help to the surgeon. Paravertebral and sacral block should take the place of spinal anaesthesia in this type of case.

In the treatment of fractures reduced one or more days after the trauma, nerve-block anaesthesia gives the surgeon sufficient muscular relaxation, and allows time enough for repeated manipulation, x-ray control of

TABLE II

SPINE AND LOWER EXTREMITIES

Diagnosis	*Operation*	*Type of Anaesthesia*	*Amount of Novocain in Grams*	*Cases*
Cervical Pott's disease.	Albee's bone graft.	Cervical, paravertebral, and spinal for graft.	0.70	1
Pott's disease, dorsolumbar.	Albee's bone graft.	Paravertebral, dorsolumbar, and sacral.	1.50	2
Fracture of the spine.	Laminectomy.	Paravertebral, two vertebrae, above and below lesion	1.10	4
Non-union of fracture of neck of femur.	Whitman's reconstruction of hip.	Paravertebral II, III, IV, V lumbar; I, II, sacral nerve.	1.50	2
Hip disease.	Extra-articular osteoplastic fusion.	Paravertebral II, III, IV, V lumbar; I, II, sacral nerve.	1.50	4
Compound infected fracture of femur.	Putti-Parham band; Orr's treatment.	Paravertebral II, III, IV, V lumbar; I, II, sacral nerve.	1.50	1
Fracture of patella.	Suturing.	Regional and crural nerve blocking.	0.80	10
Old non-union of tibia after osteomyelitis.	Bone graft (inlay).	Paravertebral II, III, IV, V, lumbar; I, II, sacral nerve.	1.80	1
Comminuted fracture of tibia and fibula.	Calf's bone plate, suture.	Blocking of sciatic nerve and regional ring.	1.00	1
Infantile paralysis.	Tendon transplantation of biceps to patella.	Paravertebral II, III, IV, V, lumbar; I, II, sacral nerve.	1.50	2
Genu valgum.	Cuneiform osteotomy of femur.	Paravertebral II, III, IV, V, lumbar; I, II, sacral nerve.	1.50	1
Hammer-toe.	Operative correction.	Regional ring.	0.30	1
Hallux valgus.	Operative correction.	Regional ring.	0.50	1
Gangrene, osteomyelitis, traumatic conditions.	Amputation of finger, leg, foot, thigh.	Regional infiltration (maximum)	1.00	8
			Total	39

results, and proper fixation, and facilitates the handling of the patient for the application of casts or splints.

Local intrafractural infiltration in the treatment of very recent fractures is used only in emergency. It has been employed in children as young as three years of age.

We sincerely believe that regional anaesthesia has a real place in orthopaedic surgery. For the reasons already mentioned, it has become the method of choice in eighty per cent. of the cases in the Orthopaedic Service of the Hospital Mercedes. In adults general anaesthesia has practically been eliminated; and in children the use of regional anaesthesia is daily increasing.

A METHOD FOR DETERMINING THE ANGLE OF TORSION OF THE NECK OF THE FEMUR

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State Hospital for Crippled Children

The neck of the femur is directed forward from the coronal plane to a variable degree. The amount of anteversion or axial rotation, measured in degrees, is called the angle of torsion. The normal angle is generally stated to be twelve to fourteen degrees, although in apparently normal femora it may vary between zero and forty-five degrees.

Significant variations in the angle of torsion occur in a variety of conditions. This study was first undertaken with reference to congenitally dislocated hips. In that condition the angle frequently approaches ninety degrees,—that is, the head points almost directly forward, so that the degree of anteversion warrants serious consideration in planning a reduction. In some cases of paralysis of the muscles surrounding the hip a significant increase in the angle of torsion is added to the coxa valga present. In slipped epiphyses, in which the epiphyseal cap is displaced backward, the angle is decreased. In malunited fractures of the neck and upper third of the shaft of the femur, disability is frequently due to derangement of the angle of torsion. Because when extremely abnormal it is a direct cause of disability, and because it so complicates the x-ray interpretation of other deformities of the upper end of the femur, an accurate determination of the angle of torsion is important in many cases.

The head and neck of the normal femur are so deeply situated in soft tissue that it is impossible to measure the angle of torsion by physical examination. Even with a dislocated hip, in which the head is palpable outside the acetabulum, only a rough estimate of the angle can be made. The information obtained from the ordinary x-ray examination is not much better. If, in a case of unilateral dislocation, we take an anteroposterior view of both hips with the patellae directed forward, we see that the shadow of the dislocated head lies almost directly over the line of the shaft, and that the neck is apparently shorter and directed more upward. We conclude from this that anteversion exists, or that the angle of torsion is increased, but we cannot say accurately what the angle is. It is worthy of note, however, that such a view gives accurate information under one condition,—namely, when the angle of torsion happens to be exactly ninety degrees, and the shadow of the head lies directly in line with that of the shaft.

If the angle of torsion happens to be somewhat less than ninety degrees, it can be calculated from x-rays of the hip region by the use of trigonometry, as follows: Two views are necessary,—the usual one taken with the patella pointing forward, and one with the thigh rotated inward sufficiently to give

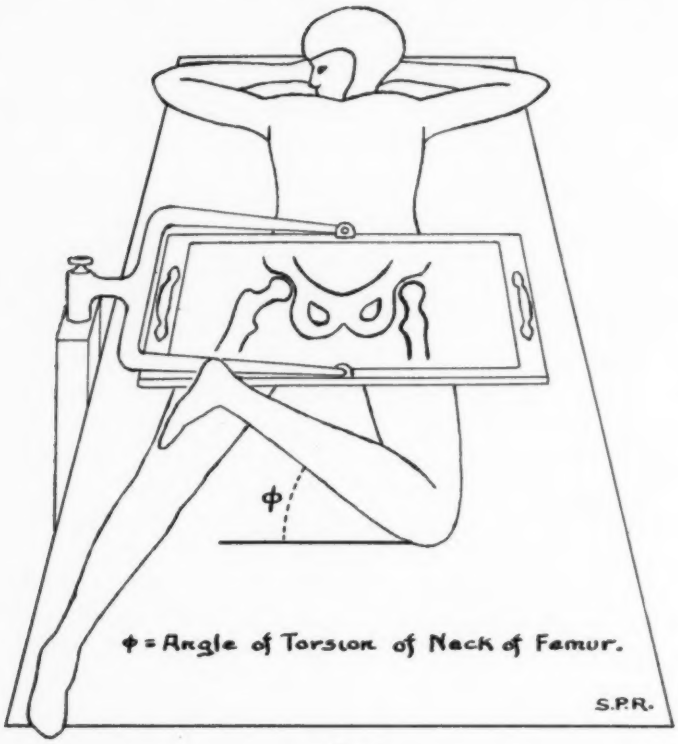

FIG. 1

Position of patient on fluoroscopic table and angle measured. Figures on screen are diagrammatic; in practice the tube should be centered directly under the hip being examined.

a true anteroposterior profile view of the neck. Then the apparent length of the neck, as shown in the first view, divided by the actual length, as shown in the second view, represents roughly the tangent of the angle of torsion. But this computation is open to two major sources of error: first, as the thigh is rotated inward, the trochanter moves farther from the film and the distortion due to projection is increased; and second, a true antero-posterior profile view of the neck is difficult to obtain except by the method to be described.

This method takes advantage of the fact that when the shadow of the head lies directly in line with that of the shaft, the axial plane of the neck lies directly in the path of the ray. It consists essentially of placing the upper end of the femur in a known position and measuring the rotation of the lower end by using the flexed leg as an indicator. The examination is made on a horizontal fluoroscopic table, as indicated in Figure 1, with the tube placed directly under the hip. The patient lies on the table face downward with the knee flexed at ninety degrees. The thigh is rotated outward, by pushing the flexed leg toward its fellow, until the shadow of the head lies directly in line with that of the shaft. The axial plane of the neck now lies

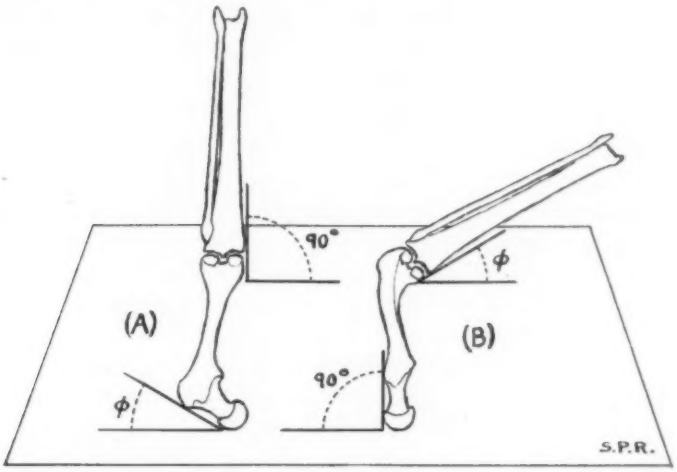

FIG. 2

Diagram representing principles involved. In *A* the coronal plane of the femur lies parallel to the table, the flexed leg lies perpendicular to both, and the angle ϕ represents the angle of torsion of the neck. In *B* the axial plane of the neck lies vertical to the table, the flexed leg is still perpendicular to the coronal plane of the femur, and the angle ϕ, measured between the leg and the table, represents the angle of torsion of the neck.

vertical to the table and the leg lies perpendicular to the coronal plane of the thigh. The angle formed between the leg and the table, therefore, represents the angle of torsion of the neck.

The mechanics of the procedure are illustrated in Figure 2. It should be noted that the factors used are the relations of the leg to the femur and of the femur to the table. The relations of the pelvis are not used. Therefore, tilting of the pelvis, which may be necessary to bring the axial plane of the neck into the path of the ray, does not introduce error. If reasonable care is taken that the tube lies directly under the hip, it may be assumed that the path of the ray is vertical to the table. It may also be assumed that the superior articular surfaces of the tibia are level, so that when the leg is flexed to ninety degrees it forms a true perpendicular to the coronal plane of the thigh. The other side of the angle, the base line on the table, must lie medial to the thigh and should be laid out approximately perpendicular to the long axis of the femur. It may also be noted from this diagram that neither the length of the neck nor the degree of its angulation upward can introduce error, because we are concerned only with the axial rotation. In coxa valga the head will appear far above the trochanter and in coxa vara it will appear superimposed upon the trochanter, but so long as the head appears in line with the shaft its axial plane lies in the path of the ray.

The only important source of error in this method lies in the lateral instability of the flexed knee under tension. In normal hips, when the thigh must be rotated outward seventy-five to eighty degrees, this error

may be as much as ten to fifteen degrees. It may be measured by bringing the screen down over the knee and noting the position of the leg required to superimpose the shadows of the condyles, and correction made by addition. But in cases with marked anteversion very little outward rotation is required to bring the axial plane of the neck into the path of the ray; therefore, the knee is not put under strain and this source of error is avoided.

This examination should require about ten seconds of fluoroscopy It should precede the making of films. Having determined the outward rotation of the thigh necessary to place the axial plane of the neck vertical to the table, films may be taken in this position and properly called lateral views of the neck. Then by rotating the thigh inward ninety degrees from this position true anteroposterior profile views of the neck may be obtained. Incidentally the latter views will show the true angulation upward of the neck from the shaft. In this view, for instance, cases of coxa valga will appear better and cases of coxa vara worse than in the usual films showing a diagonal view of the neck.

It is hoped that this method of examination may be found useful in determining the angles of torsion normal at various ages, in the study of dislocated and paralytic hips, in slipped epiphyses, in malunited fractures of the femur, and perhaps in other conditions, — all beyond the scope of this paper.

PROGRESSIVE PSEUDOHYPERTROPHIC MUSCULAR DYSTROPHY

Report of Results of Treatment with Adrenalin and Pilocarpin with an Analysis of Twenty-eight Cases

BY GARRY DE N. HOUGH, JR., M.D., SPRINGFIELD, MASSACHUSETTS

From the Shriners' Hospital for Crippled Children, Springfield

Probably no more distressing duty can be imposed on a medical advisor than that of explaining to a fond parent that their apparently robust child is suffering from a progressive disease. Particularly is this true when the disease, in the course of a few years, will totally incapacitate the child, and when no known resource of medical science can even postpone this inevitable outcome. Such a duty has faced us, in the past, whenever a diagnosis of progressive muscular dystrophy has been made. It is a task which one would gladly evade, were it not for the fact that the sole service which can be rendered in such a tragic situation is to spare the family useless expense in a fruitless search for the impossible.

Having been frequently called upon to give this hopeless prognosis, our attention was immediately caught by the report of successful treatment in twelve cases, by Kure and Okinaka[1]. With a little hope, tempered by a very strong feeling of skepticism, we undertook to get in touch with the children suffering from this disease, who had come to our attention during the past five years.

The object of this paper is to summarize the general knowledge of this disease, review our cases, and record the result of treatment to date, together with some observations in regard to the incidence, onset, and progress of the disease, made on a series of thirty cases.

HISTORY

The recognition of this syndrome dates back about a hundred years, for although Duchenne[2, 3] is commonly credited with the original description in 1849, he was really antedated by Semmla in 1834 and Costa and Gioja in 1836. Approximately twenty years after Duchenne's first contribution, he gave his more complete work, introducing the term of myosclerosis. Leyden[4], in 1876, and Möbius[5], in 1879, described certain hereditary forms. In 1883, Erb[6] clarified the knowledge of the condition by differentiating the atrophies of nervous origin from the primary myopathies, described the microscopic pathology of the muscles and presented the juvenile type which has since been known by his name. In 1884 Landouzy and Déjerine[7] described the facioscapulohumeral type, which has since been known by their names.

INCIDENCE

In none of the texts nor recent literature, so far as it has been investigated, has any attempt been made to estimate the incidence of the disease. Perhaps partly due to its striking nature and partly because of the psychological reaction to a hopeless condition, the impression is generally given that it is a disease of great rarity. However, since the opening of the Shriners' Hospital for Crippled Children, at Springfield, Massachusetts, in February 1925, twenty-seven patients have made application for admission out of a total of about 2800 applications, which is an incidence of approximately one per cent. of orthopaedic cases. These are divided by years as follows:

Seven made application in 1925
Six made application in 1926
Six made application in 1927
None made application in 1928
Seven made application in 1929
One made application in 1930

Possibly the figures for the first two years were unusually high, due to the fact that the opening of the institution was attended with considerable publicity and an enthusiastic lay organization was seeking the admission of many patients who had previously sought relief elsewhere unsuccessfully. This was our opinion at the time. It fails, however, to explain the increased number seen in 1929.

If we accept the estimates of orthopaedic diseases at six per 1000, these figures would indicate that the incidence of this disease is approximately six per 100,000 total population.

The wide-spread, practically universal distribution of the disease is indicated by the fact that during the past six years contributions to the literature have come from practically every European country, Canada, all sections of the United States, Brazil, India, China, and Japan.

The various texts agree that the male is much more subject to the disease than the female, with the ratio, when stated, of three or four to one. However, in this series of twenty-eight cases, there were no females seen, and in my previous personal experience, I have never seen a typical case in a female child.

CLINICAL PICTURE

The clinical picture is ordinarily very clear-cut and definite. The parents usually seek medical advice when the child is from four to seven years old and give a history of a disturbance in gait—usually of a strutting, waddling, or steppage type—which has been gradually increasing. Frequently there is a story of delayed walking and often the condition has been present in other members of the family. Occasionally the onset is somewhat later and may take place at puberty or in adolescence, but rarely after thirty years.

On physical examination the child is noted to stand with exaggerated lumbar lordosis and abdominal proturberance. The calves, and less constantly the glutei and quadriceps, show a characteristic enlargement termed pseudohypertrophy. The shoulders fall forward and the scapulae are apt to be prominent. There is more or less weakness of the lower spinal and pelvic muscles, which with advancing disease progresses towards the extremities. In sitting down the child is noted to fall rather heavily upon the chair, and to use the hands to rise from a sitting position. In standing from recumbency the child proceeds through a characteristic and pathognomonic series of manoeuvers, commonly spoken of as "climbing up the legs". This was described by Gower and is sometimes called "Gower's sign". After getting on his hands and knees, the child extends the legs fully, using the hamstrings to assist in stabilizing the knees. The hands are then brought back toward the feet and the shin grasped with one hand; the weight is thrown backward over the hips and the opposite leg caught below the knee. By alternately advancing the hands up the legs the trunk is raised into the erect position.

The second characteristic phenomenon is associated with the atrophy of the shoulder girdle, and is commonly spoken of as "loose shoulders". It is demonstrated by the examiner placing his hands in the child's axillae and attempting to lift him. The impression given is that of the child falling between his own shoulders. The acromion processes sometimes reach the level of the ears.

DIAGNOSIS

The clinical picture is usually so definite that there is rarely any difficulty in making the diagnosis. Occasionally, however, it is necessary to differentiate other types of chronic wasting diseases, particularly progressive muscular atrophy, or to further classify the type of myopathy. Barker[8] gives very clearly the five points of differentiation between primary myopathy and progressive muscular atrophy of neural origin. These are as follows:

1. *The age of onset.* In the myopathy, onset is usually very early and practically always before the age of thirty. In the central atrophies, on the other hand, onset is characteristically in middle or later life.

2. *Site of involvement.* In the primary myopathy, the original involvement is of the trunk and pelvic or shoulder girdles, while in the neural atrophies, in general, the more distal muscles are first involved.

3. *Family tendency.* Frequently there is a history of another involvement in the family in the cases of myopathy. With certain exceptions, such as the Charcot-Marie-Tooth peroneal palsy, this is not true of the neural atrophies.

4. *Fibrillary twitchings.* The muscles of the primary myopathies never show fibrillary twitching, which is usually present in cases of nervous origin; in fact, the presence of this condition is practically pathognomonic.

5. *Spastic phonenomena.* The presence of spasticity always indicates a primary central lesion. Rarely such a lesion might possibly be combined with a true myopathy.

CLASSIFICATION OF TYPES

There are recognized five more or less distinct types of the disease, which sometimes grade into each other.

1. The Duchenne pseudohypertrophic type. This is the most common form and is the type previously described. The cases considered in this paper are all of this type.

2. A less common type, with pseudohypertrophy occurring early in the muscles of the shoulder girdle. Apparently this form is usually of rather later onset, or slower development, or both, than the typical Duchenne type.

3. Leyden-Möbius type. This is very similar to the Duchenne type, if not identical with it, except for the absence of pseudohypertrophy.

4. Facioscapulohumeral type of Landouzy-Déjerine. This form is characterized by the early involvement of the face muscles, with the appearance of the typical so called "myopathic facies" with apathetic indifferent appearance, loss of wrinkling of forehead, and lessening of the nasolabial folds. The lips are large with the upper lip projecting in the so called "tapir lip". The power to whistle and pucker the mouth is lost. Labial letters are pronounced with difficulty. The child is unable to elevate the corners of the mouth, presenting the so called "transverse smile". The eyes can not be completely closed, causing lagophthalmus. Secondary to the facial change, there is progressive loss of power in the shoulder girdle and upper arms.

5. Juvenile form of Erb. This is similar to the facioscapulohumeral type of Landouzy-Déjerine, but without the typical facies, and usually develops somewhat later in life.

CLINICAL COURSE

As has been stated, the earliest symptoms noted are frequently delay in learning to walk and a certain amount of awkwardness in the ability of the child to handle himself. Later there is often a complaint of difficulty in going up and downstairs. The abnormality of the gait is noted and seen to increase. Then the child begins to fall more often, and to experience difficulty in getting up on his feet again, "climbing up his legs" in the manner characteristic of the disease. Ability to get about becomes gradually less, until finally the child can no longer walk. The final loss of progression is commonly associated with some temporary confinement, as will be observed in twenty-five per cent. of the cases here reported. This fact is of particular significance in regard to treatment. After the loss of power of progression, the weakness of the arms continues to increase, extending from the shoulders to the elbows and finally to the hands. Flexion deformities of the hips and knees, and equinus of the feet, which often appear while the child is ambulatory, increase markedly. In this condition of total helplessness, the child survives until at last mercifully released by death.

This gradual progression to total disability has been well recognized. However, the literature is lacking in definite statements concerning the usual

duration, or the rate of progression. In this series twenty-two children had lost the ability to walk. This incapacity occurred usually at from eight to twelve years of age, averaging about ten and varying from four to fourteen. The exact ages are given in detail under the case analysis.

The duration of disease up to the time of incapacity varied from one and one-half to nine years, was usually six to eight years, and averaged about seven years.

The involvement of the arms became evident to the parents at about the same period as loss of power to walk, at the age of about ten years. After approximately four to six years more the arm power was lost, and death followed from an intercurrent infection usually in two or three years.

PATHOLOGY

The microscopic alteration in the muscle fibers was discovered by Erb[6] in 1883. The changes which he reported consisted of true hypertrophy of the muscles with subsequent atrophy, and splitting of the muscle fibers with proliferation of the nuclei. There was also considerable connective-tissue proliferation with vascular hyperplasia and a deposition of fat in and between the muscle bundles.

Loss of anterior horn cells was reported by Holmes[9] in 1906 and subsequently by others, but these were possibly cases of progressive muscular atrophy. Rocaz and Cruchet[10] in 1906 discovered a localized degenerative lesion of the mid-brain, to which they attributed the origin of the disease. Westphal[11] reported several cases complicated by other central nervous symptoms,—such as idiocy, myoclonic, athetotic and choreiform movements—in which extensive cellular disease was found in the mid-brain, cord, medulla, pons, and elsewhere. He also quoted Foix and Nikolesco who found cellular changes in the basal ganglia of the mid-brain in cases of myopathic dystrophy. This was verified subsequently by Henke and Seeger[12] in 1927.

In one of our children on whom a surgical procedure was done, tissue was removed for histologic examination. This was Case 22, J. E. P., an eight-year-old boy with progressive disturbance of gait for six years. He had been unable to walk for one year (following appendectomy), apparently because of the extreme equinus deformity of both feet. It was thought that correction of his deformity might permit a resumption of walking and therefore a bilateral lengthening of the tendo achillis was done on September 28, 1927. The lower part of the gastrocnemius muscle was exposed and showed a marked pallor. A section of muscle was excised and sent to Dr. J. Albert Key, Director of the Research Department of the Shriners' Hospitals for Crippled Children, to whom we are indebted for the following report:

"*Gross Examination:* Specimen consists of two small pieces of soft tissue which are largely composed of fat. Both contain some fibrous tissue and what is apparently a few strands of striated muscle.

Microscopic Examination: The greater part of both sections is composed of fat and fibrous tissue. The fat is apparently normal. The fibrous tissue consists of rather coarse fibers arranged in bands which vary considerably in size and direction. It is rather dense in character and the nuclei are a little more abundant than one would expect to find in this type of tissue. Each section contains a small amount of striated muscle. The muscle fibers are about normal size. The fibers are in many places separated by a fat which infiltrates the muscle. The muscle nuclei are about normal in number and appearance. The striations in the muscle are not well defined and in some places the muscle fibers are considerably smaller than normal and the nuclei are apparently more numerous. In some places the muscle fibers are widely separated and the spaces between them contain a rather coarse basophilic precipitate, as though the tissue were oedematous and the fluid contained some albuminous substance which has been precipitated by the fixative. The blood vessels are about normal in size and number, but their walls average somewhat thicker than usual and in some places show degenerative changes and perivascular infiltration with leucocytes or round cells. There is no evidence of infection.

Diagnosis: Muscle atrophy or dystrophy." *J. A. Key.*

ENDOCRINOLOGY

It is difficult to separate fact from theory in the many statements of endocrine relationship. Goldstein[13] involves the pineal gland in the following words, "The early involution of the pineal gland gives rise to muscular fatigue, muscular asthenia, and even muscular dystrophy. The relation between the pineal gland and the tone and development of muscles is well known". He further states, "Quite a number of children suffering from muscular or motor difficulties have shown evidence of glandular dysfunction. Some of these cases which have come to autopsy show atrophic areas, tumor, infection, or inflammation of the various ductless glands, particularly the thymus, pineal gland, adrenals, parathyroid-thyroid apparatus and to some degree dyspitiutarism". He quotes Chvostek as reporting myopathies due to parathyroid disturbance, and Friederickson's report of two cases in children with adrenal apoplexy. Marie and Bouttier report a case of Erb-Goldflam's myasthenia improved by intramuscular injections of whole adrenal gland. In a case reported by Barker[8] there were definite evidences of endocrine dysfunction, consisting of a high-pitched voice, female distribution of body hair, bilateral crypt-orchidism, a basal metabolism of minus sixteen per cent., and a blood sugar of 122 milligrams per 100 cubic centimeters, which he classifies as a hypothyreo-hypogenito-hypo-insular syndrome. Landé[14] in 1926 reported a case associated with dystrophia adiposogenitalis, and Sprunt[15] refers to the unusual fatty deposits in the mammary and inguinal regions.

Janney, Goodhart, and Isaacson[16] found changes indicative of general endocrinology,—such as dryness and abnormal pigmentation of the skin, acromegalic features, brittleness of the hair, hypertrichosis, trophic changes in the nails, unusual distribution of subcutaneous fat, regressive osseous changes, marked retardation of growth, hypoglycaemia, delayed glucose utilization, and changes in the urinary contents of creatinin and creatin. Westphal[11] and Le Gendre have observed hypertrophy of the external

genitalia. Mustafaeff[17] states that all endocrine glands may be involved to a certain extent in the course of the disease. However, he does not consider this derangement as a primary causative factor, but rather as a result of the disturbance of the higher vegetative centers controlling the glands.

In our cases no definite stigmata of a disorganized endocrine system have been noted. It is our impression that a possible reason for this is that these have all been of the clear-cut Duchenne pseudohypertrophic form, while the endocrine dysfunctions are more commonly associated, perhaps, with the less typical forms occuring in later life, or with the more rare Landouzy-Déjerine type which genetic evidence leads one to believe is probably a totally different disease entity.

BLOOD CHEMISTRY

Because of the possible relationship to endocrine disturbance, considerable attention has been paid during recent years to alterations of the metabolic processes. In 1916 McCrudden and Sargent[18] reported, at considerable length, an apparently very thorough and accurate chemical study of a single patient with this disease at the Robert B. Brigham Hospital. The clinical history and physical findings are not included, and as "the patient was a man, thirty-three years of age, who showed no abnormality except progressive muscular weakness", it seems questionable whether we are dealing with a true pseudohypertrophic muscular dystrophy.

This patient was placed on a fixed diet of fifty grams of protein, 100 grams of fat and 150 of carbohydrate, and urinary studies were made daily for eight days, showing the following facts:

1. Sugar, acetone, diacetic acid, and albumin were always absent.
2. The total twenty-four hour output varied from 920 to 1450 cubic centimeters, averaging about 1200 cubic centimeters.
3. The specific gravity varied from 1.020 to 1.029.
4. The creatinin was practically constant at twenty-two and six-tenths milligrams per kilogram of body weight, which is normal, although the authors note that Spriggs[19] found a low creatinin excretion in a case of pseudohypertrophic muscular dystrophy.
5. Creatin was present in large quantities, averaging 0.413 and reaching 0.624 by the method of Folin and Dennis, which should give a negative result. This is interpreted as indicating an abnormality of glucose metabolism, being found in diabetes and in starvation associated with acidosis.
6. The ammonia nitrogen was normal for the first three days, which together with the absence of acetone bodies indicates an absence of acidosis. This, however, was before the creatin excretion reached its maximum.
7. The uric acid, total nitrogen, calcium, and magnesium determinations showed no abnormality, though the ratio of calcium to magnesium was slightly high; being a little over four to one.

Blood examinations during the same period showed normal non-protein nitrogen, uric acid, creatinin, and creatin content. The cholesterin

was very low, varying from 0.050 to 0.144 per cent., against a normal standard of 0.19 to 0.26. The authors state that while not definite this suggests a possibility of adrenal involvement.

The striking blood finding was an hypoglycaemia, with blood sugar determination of 0.0731, 0.0717, and 0.0747 per cent., against a normal of 0.09 to 0.12. The authors point out the logical connection between muscular weakness and lack of glycogen, and refer to the known facts that sugar makes exhausted muscles capable of more work[20], and that the blood sugar decreases with severe muscular work[21]. They also cite the low blood sugar (0.052, 0.033, 0.067) found in Addison's disease, and after experimental adrenalectomy in dogs[22] and in cats[13], and further refer to the association of hypoglycaemia and asthenia with dyspituitarism noted by Cushing. They further point out that the normal reserve glycogen normally contained in the cells of the liver is in these conditions of hypoglycaemia replaced by fat deposits. This suggests that the fatty deposits in the pseudohypertrophic muscles may be due to a perversion of the deposition of glycogen in that reservoir.

The cause of the hypoglycaemia is assumed to be a loss of balance between the rate at which glucose is introduced into the blood and the rate at which it disappears from the blood into the muscles, renal diabetes having been excluded; and since the formation of glycogen from glucose, and the reverse, is controlled by the adrenals, the pituitary, and the thyroid, it was thought logical to treat this case with epinephrin and pituitary extract. This was done with prompt and marked improvement in health, strength, and weight, with a blood sugar increase to 0.080 and then 0.099.

A case reported by Goldstein[13] of an eight-year-old boy able to walk only a short distance, in whom the onset dated back to the age of thirteen months, showed a blood sugar of 80.

A case reported by Barker[3] of a fifty-five year old Esthonian tailor with slowly progressive disease for twenty-seven years showed a blood sugar of 122.

Moren[24] quotes two cases of Dr. Farnell who had a fasting blood sugar of 90, with a high sugar tolerance. Clinical improvement was obtained in these cases by a high carbohydrate diet.

HEREDITY

As has been previously mentioned, it is not uncommon to see two or more cases of the disease occuring in the same family. This fact is striking, and was observed very early in the study of the disease. Characteristically the disease appears in brothers, and occasionally in cousins; but it is not usual to obtain any history of the disease in preceding generations.

In this series there were three pairs of brothers with the disease, or slightly more than ten per cent. In one other case there was a suggestive indefinite history of a similar disease in a maternal cousin. The relation of a family history of syphilis to the disease has received considerable attention and this was reported by the family physician in one of our cases. Further reference to this point will be made under the heading of associated

diseases. Goldstein[13], quoting Camp, Hertz and Johnson, reported cases of progressive muscular atrophy whose descendents showed myopathies. It is uncertain what significance, if any, this fact may have.

Recently there have been several studies of the hereditary nature of the disease which have contributed important data to our knowledge of the condition. Chief among these is the work of Minkowski and Sidler[25] who studied the hereditary nature of this disease in a secluded Swiss valley, where family records were available as far back as the sixteenth century. No cases occurred for many generations, when there was a sudden explosive outbreak of muscular dystrophy in the descendants of the families of R. and H. among whom there had been many intermarriages. These authors conclude that inheritance of the disease occurs according to the recessive mode in the mendelian sense. Homogametes (*i.e.* cases of disease) would appear only from heterogametic marriages. The anlage or genotypic rudiment of the disease apparently must be present in both parents, for they found the disease only where each parent had been derived from both the H. and R. strain, indicating a double mendelian recessive process. Further, it seemed certain that the pathologic gene must have been present in these strains for at least 300 years. They found no evidence of a sex-linked inheritance. These cases were of the Duchenne type.

Contrary evidence appears in certain genealogical trees of families with the Landouzy-Déjerine type in which the disease exhibited a mendelian dominance. Barker[8], in discussing these facts, presents this as proof that the two conditions are totally different diseases, although clinically similar.

ASSOCIATED DISEASES

Two types of conditions have been reported associated with this disease,—namely hereditary syphilis and lesions of the central nervous system. Cadwalader and Corson-White[27] reported several cases in hereditary syphilitics in 1913. Rollin[26] in 1927 reported five cases in children whose parents had syphilis. In one of our cases a family history of syphilis was reported by the family physician, but there was no evidence of the disease in the child.

Westphal[11] and Petenyi[28] have reported cases associated with an extrapyramidal symptom complex. Westphal has also reported cases associated with idiocy and epilepsy. It will be noted that one case in this series (Case 23) shows definite mental deterioration. Werthemann[29] and also Camp have reported cases associated with familial cerebellar ataxia. Camp also has reported association with hereditary optic atrophy. Gerstle and Goddard[30] reported in 1929 a case associated with acute meningeal syndrome. Steinberg[31] cites Oppenheim's quotation of a case associated with anterior poliomyelitis which is similar to Case 28 in this series.

PATHOGENESIS

Erb[6], in his original contributions to this subject, held the theory that the primary cause of the disease was a lesion of a trophic center in the

central nervous system. This theory was subsequently abandoned, but it is interesting to note how more recent suggestions as to the pathogenesis are again turning about a similar hypothesis.

In 1914 Adami and McCrae[32] stated, "The condition is thought to be an example of abiotrophy in which the muscle starts life with less than the proper molecular energy. It has little bearing on the pathological condition that the disease in its early stages shows hypertrophy, for this is only apparent, occasioned by the intramuscular fatty deposit." There is something almost hippocratic in the theoretical speculation of this explanation.

The thought of those investigators who hold the endocrine theory of pathegenesis has already been stated, and while the exact relationship is still uncertain there is probably some association, at least in some of the cases. Barker[8] quotes the theory that there is a primary defect in the sympathetic innervation of the sarcoplasm of the muscle fibers, which might be due to insufficiency of the internal secretion of the suprarenal capsules. Stscherbak[33] has also expressed the opinion that the fundamental disturbance was due to an adrenal insufficiency.

Kure[1], to whom we have acknowledged our indebtedness, has been working on the problems involved in this disease for the past ten years at his clinic at the Imperial University at Tokyo, and his article contains a bibliography of eighteen papers by himself and his associates, including Shinosaki, Kishinoto, Sato, Hoshino, Tsuki, Hatano, Kai, Nagano, Tsuji, Imagawa, Sunaga, Matsuma, Mitta, Kimura, Sakurasawa, Nakarowa, and Kojina. They have brought forward evidence to substantiate their conclusion that the basic disturbance is an alteration of the autonomic innervation of the muscles, and it is on the basis of this experimental work that Kure developed the rational basis of his treatment. Slauck[34], Christensen[35] and Mustafaeff[17] have also contributed work on this aspect of the disease. Rocaz and Cruchet, Henke and Seeger, Foix and Nikolesco, and Westphal have recently advanced the theory that the probable origin is to be found in a localized degenerative lesion of the mid-brain. This perhaps represents the trophic center which Erb assumed. Schilder and Weissmann[36] recently reported two cases following encephalitis, as has Klien[37] also, while Gerstle and Goddard[30] reported a case with acute meningeal symptoms. It is suggested that in these cases an acute infectious lesion of the trophic center of the autonomic system is the origin of the disease.

TREATMENT

In the past, treatment has been felt to be of no avail in improving or even arresting the progress of the disease. From the general principles of orthopaedic treatment, it is recommended in the standard text-books to correct the equinus deformity when this occurs. This, however, is frequently disastrous, as is so well illustrated by Cases 15, 20, and 27 of this series. In each of these cases the equinus was corrected by a different procedure, representing the three possible methods of correction,—namely, tenotomy of the tendo achillis, open lengthening of the tendon, and simple

manipulative stretching. In each case the operation was successful, but the patient never walked again. In Case 22 the same result followed an appendectomy for acute appendicitis, indicating that it was not due to the correction of the deformity but rather to the enforced cessation of activity. Apparently this is an example of the force of inertia. The child is able to keep going from day to day, but when once forced to give in, there is insufficient strength to resume activity again. These children were aged ten, eight, eight, and nine years, respectively, at the time of operation and had been suffering from the disease for eight, three, four, and eight years.

In 1896 Weiner, according to Moren[24], reported an apparent cure in a boy twenty-two years old, by the systematic use of gymnastic exercises, after other therapeutic measures had failed to produce any improvement. This would appear to be a very unusual case and, as Moren[24] points out, apparently cases developing later in life offer a better prognosis. Goldthwait[38], in reporting the case previously referred to by McCrudden and Sargent, attributed good results to the correction of lordosis, and enteroptosis. Moren quotes Oppenheim and Gordon as considering galvanic stimulation of benefit, but expresses his own opinion that massage is more useful, although its benefit is insufficient to really check or improve the condition.

High carbohydrate diet has resulted in improvement according to Eaton and Farnell, quoted by Moren[24]. Activity was increased, function improved, and the onset of fatigue delayed. No statement is made concerning any influence on the progression of the disease.

In regard to medicinal treatment, Stscherbak[33] and others have advocated the use of calcium. Barker[8] refers to this treatment and states that more experimentation is necessary before any real value can be attributed to it.

Occasional articles have appeared during the past fifteen years, reporting favorable temporary results in isolated cases from the use of various endocrine preparations,—namely thyroid, pineal, pituitary, testical, ovary, and particularly adrenalin. These have been followed by other reports of failures with the same type of preparations. Herrmann and Kral[39] recently reported several cases with very marked improvement following the use of hypertherman injections combined with extracts of testis and ovary. This substance he claims to act as an altering principle producing an allergic condition sensitive to small doses of gonadal substance. Mustafaeff[17] has contributed the most recent study on the effect of adrenalin, reporting on thorough use in six cases. His conclusions were: (1) No evidence could be found to show that the adrenals were affected in progressive muscular dystrophy. (2) Adrenalin has a symptomatic effect, stimulating the sympathetic nerve endings and thus increasing muscle tone. (3) Adrenalin therapy is not very effective, in spite of some temporary improvement.

Such was the unsatisfactory status of treatment previous to the publication of the results of Kure and Okinaka[1]. Their method of treat-

ment consisted of the subcutaneous injection of two-tenths to three-tenths cubic centimeters of one per cent. solution of adrenalin and one-tenth to two-tenths cubic centimeters of one per cent. solution of pilocarpin hydrochlorid, given daily or every second day up to fifty or sixty doses without interruption. This is the method of treatment which we have followed in our cases. Because of the significance and importance of their work and the fact that the English literature contains no reference to it, we have quoted their results and conclusions in detail.

They reported that in all twelve patients treated, a definite increase in strength of the dystrophic muscle was observed usually two or three hours after the injection, persisting ordinarily for about twelve hours. After repeated doses there was increasing strength. In one case improvement occurred after thirty injections. Improvement in strength which appeared after fifty to sixty injections lasted months after stopping injections.

In two of their twelve cases, they obtained astonishing results. A girl, who could walk with crutches barely 100 meters, was able immediately after forty injections to walk four to five kilometers without crutches. Her body weight (44.8 kilograms) was increased during the treatment to forty-seven kilograms. Two months after the treatment her gait was only a little worse. A boy who could raise his arms barely to the horizontal, after sixteen injections could raise his arms to forty-five degrees above the horizontal. After fifty injections he could hold his arms upright. The musculature was so markedly hypertrophied that this was scarcely considered possible. The circumference of the thighs (twenty centimeters above the middle of the patella) was before treatment: right, thirty-one centimeters; left, thirty-five centimeters; and at the end of treatment: right, thirty-three and five-tenths centimeters and left, thirty-seven centimeters. Following his discharge, he could carry on his work as a tiller of the soil without trouble. Three months after his discharge there was no recurrence of symptoms. In these two cases such outstanding improvement was made that one can speak of a functionally complete cure.

Six other cases showed definite improvement which was demonstrable by the ergograph. Distinct accomplishments and support of the body, which were scarcely possible before the treatment, were effected more easily after the treatment. The last three cases, in which there was advanced disease, complicated by spinal progressive muscular atrophy, showed no definite result from the treatment but, as the authors state, it could not be expected that the progression of dystrophy which had gone on to the last stage would stop during the injection. The result of the treatment was proportionally better in the earlier and less complicated cases. The writers further expressed the opinion that the use of the affected muscles during the injection is necessary for a *restitutio ad integrum*, and accordingly a certain amount of strength must remain in the dystrophic muscle.

The improvement appears during the first fifty injections, and if no benefit can be shown, the outlook is very doubtful. The only undesirable

reactions produced by the treatments consist of palpitation produced soon after the injection. After fifty to 120 injections neither cardiac hypertrophy nor an increase in blood pressure was evident.

As to the significance of the treatment, Kure and Okinaka have a somewhat different view from Stscherbak, who believes that certain cases of dystrophy can be completely cured by adrenalin injection. They state that although they have obtained a striking improvement and a practically complete reestablishment of normal function in favorable cases, they do not believe that dystrophy by this treatment can be permanently and completely cured. It is possible that dystrophy will return following the interruption of adrenalin and pilocarpin, but since the progression of dystrophy is very slow, one can stop the spread of the disease through repeated courses of treatment. In this sense they believe the treatment to be worthy of recommendation, because at present no better method of treatment is known.

They summarize their results as follows:

1. Adrenalin and pilocarpin injection are of therapeutic value in muscular dystrophy, at least in checking the continued progression of the disease. Injections were repeated daily or every other day. In most cases over fifty injections were given. Good results were observed usually within fifty injections.

2. With the exception of palpitation, the treatments had no untoward reaction, especially in regard to cardiac hypertrophy and elevation of blood pressure.

Stimulated by the reported results of this treatment, we undertook in November 1930 to get in touch with all of the children suffering from this disease who had made application for admission to this hospital, in order to give them any possible benefit which the injections of adrenalin and pilocarpin might offer, and, at the same time, to obtain additional data in regard to the disease. The following case histories and their analysis present the results of our investigation.

CASE HISTORIES

CASE 1. C. A. of Lowell, Massachusetts, was born in October 1912 and was normal up to his eighth year, when the symptoms were first noticed. The onset was associated with pain in the right knee. There was a gradual progression up to the time when he was first seen in May 1926, at which time he had been unable to walk for several months. In November 1930, in reply to our letter of inquiry we were informed that he was totally helpless except for the ability to move fingers. In spite of the apparently absolutely hopeless situation, treatment was started through the cooperation of Dr. Theodore Stamas sometime in December 1930 and, after January 20, 1931, continued through the coopération of the Lowell Visiting Nurse Association. Dr. Stamas reported, on February 21, 1931, that patient had received fourteen cubic centimeters with improvement in muscle tone.

CASE 2. A. A. of Providence, Rhode Island, was born February 2, 1917. When seen in May 1926, he presented a typical moderately advanced case, still able to walk, but with considerable difficulty. Symptoms were first noted at the age of three in 1920

when parents observed difficulty in going up stairs.The disease had been gradually progressive for six years. There was marked weakness of arms at age of six. When ten years old he lost his ability to walk, and, on June 30, 1930, he died following an acute illness of three days' duration diagnosed as pneumonia.

Case 3. A. G. B. of Lebanon, New Hampshire, was born in May 1916 and was nine years old when first seen in 1925. The onset was dated from 1920, following an acute illness characterized by high temperature and pain in legs. When first seen he presented a typical picture of moderately advanced disease, still able to walk but requiring assistance in starting. In September 1928, he totally lost his ability to walk. In response to our letter of inquiry in November 1930, we learned that he was helpless except for slight use of forearms and hands and was unable to turn over in bed or lift anything of any weight. Treatment was started through the cooperation of Dr. Harry W. Savage, of Lebanon. Following thirty injections, Dr. Savage reported very marked improvement. Glycosuria developed during treatment, causing its temporary suspension. Dr. Savage reported that, following treatment, the child could feed himself, manipulate his wheel chair, and move his feet somewhat. A discoloration of the skin previously present had disappeared, and his general appearance was much brighter. There was marked diminution in the size of the pseudohypertrophic muscles, and he was able to sit erect. No reflexes were obtainable.

Case 4. K. B. of Lincoln, Maine, was born in October 1921. Difficulty was noticed in early infancy and there was definite delay in learning to walk, which was not accomplished until the age of twenty-one months. It was noticed very early by the parents that it was particularly difficult for the child to get up from the floor after falling. When seen in December 1929, he presented a typical picture of a moderately advanced case, was still able to walk, but with very marked disturbance of gait.

The family history was very suspicious of a case of progressive muscular dystrophy in a maternal cousin. Two other boys in the family were normal. In response to our inquiry of November 1930, we were informed that there had been gradual progression of disability, with loss of power to walk three months previously. The power in the arms was reported as normal. Treatment was started through cooperation of Dr. H. W. Ball of Lincoln, Maine, who reported definite improvement following a series of thirty injections. The boy is now able to get into a chair with some difficulty, while previous to treatment this had been entirely impossible. His facial expression was noted to have improved markedly and in the words of Dr. Ball, "He is now real lively". Previous to treatment urinary incontinence was present, which was relieved during the treatment. Dr. Ball notes fixed knee flexion deformity and bilateral equinus.

Case 5. T. C. of Longmeadow, Massachusetts, was born in 1917 and was the first son. Two older sisters were normal and a second boy was born subsequently who is apparently normal. Patient was slow in learning all the usual activities and walked at eighteen months. Following this initial delay, however, childhood was moderately normal up to five or six years of age, when parents admitted to themselves that something was wrong. At first there seemed to be undue fatigue, and then gradually increasing weakness. He fell frequently and "climbed up his legs" in the characteristic way. He was seen in September 1928, when he presented a typical picture of a moderately advanced case. He was still able to walk with a strutting gait, extreme lordosis, and moderate bilateral equinus. He fell easily and was unable to get up without assistance. The calves showed typical pseudohypertrophy and there was marked shoulder-girdle relaxation. The arms showed fair strength. The abdominal muscles and erector spinae group were very weak. In the hips the extensors and adductors were poor, but the abductors and flexors were good. The quadriceps could not hold against gravity, and the calves were the only active muscles in the feet. The hopeless prognosis was explained to the family, and a light back brace was applied in hopes of prolonging activity by supporting the lumbar spine. This, however, was of no help, and about two months later, at the age of eleven, he ceased being ambulatory. On January 6, 1931, treatment with adrenalin and pilocarpin was started. There had been gradual loss of power in the arms which, however, were still useful. He could not lift his arms over his head, but was

able to maintain horizontal abduction for more than one minute. All motions of arms could be executed against slight resistance. There was forty degrees' bilateral knee flexion and marked equinus. After three weeks of treatment with adrenalin and pilocarpin, definite objective and subjective improvement in strength of arms could be noted. There was also improvement in appetite.

Case 6. A. C. C. of Fairview, Massachusetts, was born in 1912. Onset of disease was first noted at age of six in 1918, and, at time of application in March 1925, he had been unable to walk for an unknown period of time. On following up this case, it was found that the boy died in 1928 of unknown cause, having been totally disabled for a considerable period prior to his death. Two younger brothers appeared to be perfectly normal.

Case 7. H. C. of New Bedford, Massachusetts, was born February 4, 1920, and was perfectly normal up to the age of six years, when the first symptoms were noted. When seen in August 1930, the boy presented a typical picture of early stages of the disease. There was moderate disturbance of gait. He fell easily and experienced moderate difficulty on getting up after falling. Through the cooperation of Dr. William McDonald of The Haven, Marion, Massachusetts, treatment was instituted. The following is from Dr. McDonald's report: "I began the treatment with considerable skepticism; and to my astonishment, at the end of three weeks of treatment, I noticed that the large mass of fatty tissues in his calves had almost entirely disappeared; I found that he could raise his body onto the toes, lift both heels from the floor, and he could also support the entire weight of his body on one toe alone. I tested him in a number of other ways and found great improvement. He not only stands erect, but can actually run. He volunteers the information that he seldom falls as he did formerly. The most conclusive evidence of his improvement is given by his mother, who previously was about as pessimistic as a mother could be relative to the condition of her son. She has written me a letter thanking me for what has been done and stated frankly that she is delighted with the positive improvement shown."

A subsequent report, on March 2, 1931, stated that condition remained satisfactory.

Case 8. E. F. C. of Gloucester, Massachusetts, was born June 20, 1915, and although no definite abnormality was noted until the age of four, there was some delay in walking as gait was not established until the age of sixteen months. When seen in August 1927, he had been unable to walk for one year. In response to our letter of inquiry in November 1930, we were told that the boy was helpless, except for a little power in his arms,—enough to enable him to dress himself. After fifteen injections given through the cooperation of the district nurse in Gloucester, glycosuria developed.

Case 9. C. D. of West Sullivan, Maine, was born September 21, 1919, and it was noted at the age of two and one-half years that he swayed sideways when he walked. There was gradual progression, with loss of ability to walk in 1923. Treatment was instituted by Dr. R. A. Black of West Sullivan, Maine, December 12, 1930, and on January 25, 1931, Dr. Black reported: "The mother says she thinks he can move his limbs better. However I cannot see much of any improvement. I have observed no change in the patient, mentally or physically."

Case 10. N. W. D. of Hornell, New York, was born April 21, 1916, and although no difficulty was noted until 1918, he did not learn to walk until he was about two years old. The first symptom noted was slowness in getting up stairs. There was gradual progression of symptoms, with loss of power to walk in 1925. In response to our letter of November 1930, we were informed that there was marked involvement of the shoulders with inability to raise the arms. Through the cooperation of Dr. William J. Tracey of Hornell, treatments were instituted, with a report of improvement in appetite, with a subjective sensation of stretching in the muscles in the legs, and a desire for them to be extended instead of flexed. A transient glycosuria was noted after a sixth injection.

Case 11. E. L. D. of Malden, Massachusetts, was born March 21, 1922, and the first symptoms of the disease were noted in 1925, particularly difficulty in going up stairs. When seen in August 1929, he was able to walk with considerable difficulty, and this power was lost in April 1930. In response to our letter of inquiry in November

1930, we were informed that the boy seemed in splendid health in every way, except for his muscular weakness. He was then able to get about on a kiddie car and it was noted that the arms were becoming progressively weaker. Through the cooperation of the Malden Community Nursing Association, eight injections were given. Three hours following the eighth treatment, there was a reaction consisting of stomatitis and feeling of exhaustion persisting for about seven hours. Injections were resumed after five days, and no further reactions were noted. After thirty treatments the mother said that the patient "moves his body more easily". There has been some subjective sensation of tingling in the legs.

Case 12. H. M. E. of Belfast, Maine, was born August 2, 1920, and commenced walking at about the age of fifteen months. In 1923 he broke his leg, following which he never seemed to recover a normal gait. Symptoms were definitely noted at the age of five years. In September 1929, he was walking with some limp. The family history in the case was reported by the family physician to be suggestive of a syphilis, but the boy himself showed no evidence of the disease. In response to our letter of inquiry of November 1930, we were informed that the boy was able to walk for short distances but fell very frequently. Through the cooperation of Dr. Foster C. Small of Belfast, the local chapter of the Red Cross, and Mr. Claud F. Clement (the Shriner interested in the case), treatment was instituted and at the end of three weeks improvement was noted. The gait was better, and the muscles were observed to have a better tone. An improvement in the mental condition of the boy was also reported.

Following a second series of thirty injections, strength and gait showed additional improvement, but lordosis was increased.

Case 13 and Case 14. L. H. E. and F. J. E. of Worcester, Massachusetts.

Lewis was born in November 1912, and showed his first symptoms of the disease at the age of seven. The condition gradually progressed, with loss of ability to walk sometime previous to August 1926, and on April 8, 1927 he died of pneumonia, after a three-days' illness.

In attempting to follow up this case we learned about a second son, Frederick, who was suffering from the same condition. He was born December 28, 1916, and difficulty in walking was first noted in 1921. This gradually progressed, until in 1927 he became unable to walk. In November 1930, very little power was left in the arms. Treatment was advised but no report of result has been obtained.

Case 15. H. A. H. of Springfield, Vermont, was born in September 1912 and was normal until October 1914, when he had an acute illness, characterized by fever and inability to walk for one week. Following this illness, there was gradual progressive loss of power and disturbance of gait, until in 1922 tenotomony of the tendo achillis was done for the correction of equinus. Following this operation, he was never again able to walk. He was seen in 1925, at which time he presented a typical advanced stage of the disease. This slowly progressed to total helplessness, until he died, in September 1929, from an acute gastro-enteritis.

Case 16. H.O.H., brother of Case 15, H.A.H. He was born in August 1913 and was normal until October 1914, when, coincidentally with his brother, he was taken ill with an acute febrile disease, lasting for two days and followed by complete loss of power in the left leg. This disability slowly improved, but the typical loss of function associated with progressive muscular dystrophy gradually became manifest. In 1923 he lost the ability to walk and, when seen in 1925, presented a typical picture of the advanced stage of the disease. This continued until his death, in February 1929, from influenza and probable pulmonary tuberculosis.

Case 17. E. J. of Willimantic, Connecticut, was born in October 1911, and symptoms of muscular dystrophy were noted during infancy. The disease was gradually progressive, with loss of power to walk in 1920 at the age of nine years. He died of pneumonia, after one week's illness, on March 9, 1928, aged seventeen, eight years after the loss of power to walk, and after sixteen years of the disease.

CASE 18. R. J. of Sanford, Maine, was born May 31, 1918, and showed slight delay in starting to walk at eighteen months. Between the ages of two and two and one-half, difficulty in stepping up on the curbstone and walking up stairs was noted. There was gradual progression of the disease, and in May 1923 tenotomies of the hamstrings and Achilles tendons increased his disability. In November 1926, he had scarlet fever, followed by measles, and in May 1927 lost ability to walk. He was seen in June 1927, when he presented a typical picture of a moderately advanced stage of the disease. In reply to our letter of November 1930, we were informed that there had been little change since his examination, except for increasing deformity of the legs and slight weakness of the arms. Treatment was advised, and following four weeks of it his mother reported: "I cannot see any great change, but do think I can see a difference in him. One leg does not seem so hard and tight and he said the other day he thought he could straighten them out a little more. He seems to have more life and acts as if he felt better."

In September 1931, following ninety injections, his mother observes more energy and better use of arms and legs. The total improvement, however, has been slight.

CASE 19. R. R. M. of New Haven, Connecticut, was born in 1919 and symptoms were noted during infancy. In December 1926, at the time of his application, he was able to walk without assistance.

Attempts to ascertain Robert's present condition were finally successful through the crippled children's room of the New Haven Public Schools, on March 25, 1931. At this time he was unable to walk, had very little strength, and had to be supported continually. A second son, Stephen, aged ten years, was suffering from the same condition and was unable to walk. A third child, aged seven years, was beginning to show similar symptoms.

CASE 20. P. J. M. of West Hartford, Connecticut, was born October 16, 1920, and symptoms were noted at the age of five years. These were reported by the parents as consisting of awkward and slow movements, and a difficulty in handling himself. When seen in October 1926, he presented a typical picture of a moderately early stage of the disease with characteristic strutting gait. In September 1928, tendon lengthening of the Achilles tendons was done by a leading orthopaedic surgeon, following which the boy was never able to walk. In October 1930, he was admitted to the Newington Home. In response to our letter of November 1930, we were informed by the superintendent of that institution that there was very limited use of the arms. We suggested treatment in this case, which was declined.

CASE 21. F. P. of Portland, Maine, was born in September 1915 and was well until the age of ten. In 1925 he had an acute illness diagnosed as flu. Following this illness he could walk a little on the balls of his feet, but would fall frequently. The loss of power increased and in 1927, two years after the onset, he was unable to walk. In response to our letter of November 1930, we were informed that the power in his arms was gradually disappearing, the first weakness having been noted in the spring of 1929. There was apparently some mental deterioration also, as the father stated that the boy acted like a five-year-old child. Treatment was instituted through the cooperation of Dr. Hall of the Maine General Hospital in December 1930, but was interrupted by the appearance of glycosuria. On March 25, 1931, the father wrote that slight improvement had been noted before the completion of thirty injections.

CASE 22. J. E. P. of Corinna, Maine, was born November 15, 1917, and disturbance was noted in infancy. He walked at eighteen months, but his father stated, "When learning to stand up, he would not stand without climbing up himself or crawling to some object to climb up by". In 1926, following appendectomy for acute appendicitis, the power to walk was lost. In response to our letter of November 1930, gradual loss of shoulder power was reported. Treatment was instituted through cooperation of Dr. Joseph J. McVety of Corinna, who reported after six weeks, "I cannot see any improvement, although parents and children at school think he can handle his arms and hands better and has more strength in his fingers".

CASE 23. F. M. R. of Leominster, Massachusetts, was born June 11, 1920. Difficulty in getting up after falling was noted at age of two in 1922 following pneumonia. In December 1929, at the time of his application, he was said to walk without limp but to fall easily. In response to our letter of November 1930, he was reported to be walking slowly and with difficulty, and to show weakness of the arms.

Before treatment was started, however, he gave up walking. Treatment was carried out through the cooperation of the Red Cross Chapter at Leominster. Following thirty injections, his mother writes that the muscles are smaller and do not seem so tight. A total of 120 injections have been given in this case. Gait has not been reestablished, although he is able to stand alone. The arms are stronger and hypertrophy less marked.

CASE 24. J. R. of Albany, New York. He was born in 1918, and symptoms were noted in 1923 at the age of five years. At the time of his application, in June 1929, he was unable to walk. Subsequent attempts to get in touch with this child have been unsuccessful.

CASE 25. L. R. S. of Springfield, Massachusetts, was born March 6, 1916, and symptoms were noted during infancy. When he was about nine months old, his mother observed that it was hard for him to sit up and he would fall over very easily. At one year of age, he walked holding on to objects, and alone at eighteen months. When first seen in August 1925, he presented the typical picture of moderately advanced progressive muscular dystrophy, walking with difficulty. In December 1926, at the age of ten years, he lost the ability to walk. In May 1929 there was marked loss of power of the arms, and in May 1930 he was entirely unable to raise his arms. The treatments were started on December 17, 1930, and after thirty injections there was subjective improvement in so far as he stated that he felt stronger and used his hands better, and his mother observed that he appeared more lively and showed more interest in his surroundings. Objectively there was a slight increase in the power of his grip in both hands. The slight but definite improvement in muscle strength in hands continued during ninety injections and has persisted for six months since stopping treatment.

Following interruption for two weeks, a second series of thirty injections was given with continued improvement. He is now able to sit erect by holding on with his hands, after being assisted into this position. Dorsiflexion of both wrists is possible against moderate resistance,—more in the left than the right—and the hands are stronger.

CASE 26. R. H. W. of West Springfield, Massachusetts, was born April 12, 1919. He was apparently normal during infancy, walking at eighteen months. In 1923, at the age of four years, he had an acute febrile illness with gastric symptoms and loss of power in the right leg, which was apparently in every way characteristic of anterior poliomyelitis, which was the diagnosis at the time. In 1925 he came under our observation, the case being referred as a residual paralysis of poliomyelitis, as which it was accepted. In looking back, one can see that at that time there was a suggestive enlargement of the calves. The paralytic condition responded well to treatment, but it soon became apparent that there was a definite progressive muscular dystrophy. In November 1927 this reached a moderately advanced stage, and in November 1928 he was unable to stand up without assistance. In March 1928 he started the use of crutches. In September 1929 he was unable to stand, and definite loss of power in the arms was observed. Treatment was started on December 17, 1930, and after thirty treatments improvement was noted in increased strength in arms with ability to elevate them over his head. His home school teacher reports increased ability with his school work; and the boy states that he feels better and takes more interest in things.

CASE 27. C.W. of Holyoke, Massachusetts, was born on October 7, 1920, and was apparently normal until four years old, learning to walk at between thirteen and fourteen months. The first symptom noted was falling without any apparent reason, and this gradually increased. In 1928 the feet and legs were manipulated to correct the knee flexion and equinus deformities and he never walked again. In August 1929 he lost ability to turn over in bed. In April 1930 he could use his arms only a little, and in response to our letter of November 1930, his father reported that he was gradually losing the remaining power in his arms.

A series of thirty injections of adrenalin and pilocarpin was given during January 1931 with definite improvement. Following the treatment, he was able to sit erect with help of his arms; this had previously been impossible. At the conclusion of treatment he had an acute respiratory infection from which he almost died, and during the acute illness treatment was not resumed. He was examined on April 1, 1931, before the resumption of a second course of injections, and he had maintained the improvement obtained during the first course. The grip in both hands is very weak, and motions of the forearm can be executed only partially against gravity. The arms can be abducted about thirty degrees. He is able to sit erect and maintain his body balance without use of his arms. There is practically no power in his legs which show thirty degrees' bilateral flexion deformity of the knees and marked equinovarus. Two additional courses of treatment failed to show any additional improvement.

CASE 28. T. L. Y. of Franklin, New Hampshire, was born in 1916 and symptoms were first noted at the age of four years. In April 1926, when his application was made, he was still walking. Efforts to obtain further information and to start treatment have been unsuccessful.

ANALYSIS OF CASES

Onset

In six of these cases (Cases 3, 15, 16, 21, 23, and 27), the onset has been associated with an acute febrile disease compatible with an acute central nervous system injection. One of these cases (Case 26), which was seen relatively early, was clinically typical of infantile paralysis, and two others (Cases 15 and 16), were very suggestive. This is of particular interest because of the possible association with the pathological lesions of the mid-brain, described by Henke and Seeger. It is also interesting in view of the other cases in the literature, associated with various other central nervous system disorders. The ages of onset in these cases were four, two, one, ten, four, and four years, respectively. They showed nothing in their clinical course, which differed from other cases of the disease.

Deaths

Six of the series (Cases 2, 6, 13, 15, 16, and 17), have died since 1925. At the time of death, one of these patients was thirteen years, two were fifteen, one was sixteen, and two were seventeen years old. The immediate cause of death was pneumonia in three cases, unknown in one, influenza and pulmonary tuberculosis in one, and gastro-enteritis in the other. The duration of the disease was eight, ten, sixteen, fourteen, fifteen, and sixteen years, respectively. The interval from the loss of locomotion to time of death was more than one year in the first case, three years, more than three years, and five, seven, and eight years in the others.

Age at Onset

Ten cases, where the age at which the child started to walk is known, all showed some delay in walking. Five children walked at eighteen months, while the others were fourteen, fifteen, sixteen, twenty-one, and twenty-four months, respectively. The onset, as observed by the parents was during infancy in six cases, at two years in five cases, at three years in three cases, four years in five cases, five years in four cases, six years in two cases, and one case each at seven, eight, and ten years.

Progress to Loss of Walking

Three children are still walking, at the age of ten years. In these cases symptoms have been present for four, six, and seven years. The exact time of loss of power to walk is not known in four cases, but was before the age of eleven, twelve, thirteen, and fourteen, with a duration of disease less than six years in one, seven years in two, and eleven years in the fourth. In the remaining cases, the loss of power to walk occurred at the age of four, eight (3 cases), nine years (5 cases), ten years (6 cases), eleven years (3 cases), twelve years (2 cases), and fourteen years. The duration of disease in these cases was one and one-half, two, three (2 cases), four, five, six (4 cases), seven (6 cases), eight (3 cases), and nine years (2 cases).

Present Condition

The twenty-two children now living vary in age from eight to eighteen years; they are eight, nine, ten (6 cases), eleven (3 cases), twelve (2 cases), thirteen (2 cases), fourteen (4 cases), fifteen (2 cases), and eighteen. Symptoms have been present from five to twelve years. Only three are still able to walk. The children under ten years of age show relatively little involvement of the arms; two of the children ten years old and one of those aged eleven show fairly marked loss of arm power. The children thirteen years and over show very extensive loss in the arms, with the exception of one boy, now aged fifteen, in whom the disease is only of five years' duration and in another the arms show only a little weakness. One of the fourteen-year-old boys and one aged eighteen, in both of whom the disease has been present ten years, show only very slight power in the hands, being otherwise totally helpless.

Results of Treatments

In sixteen cases there has been a report following treatment with subcutaneous injections of adrenalin and pilocarpin. Every case showed some improvement in spite of the fact that many were in an extremely advanced stage of the disease, far beyond a time when much could possibly be anticipated. In eight of the cases,—namely Cases 1, 9, 10, 11, 18, 21 22, and 25, the improvement was slight. In 4 (Cases 5, 23, 26, and 27), the improvement was moderate, consisting of a very definite objective increase in strength. In four (Cases 3, 4, 7, and 12), the improvement was marked. These represent relatively early cases, in which the possibility of help might be expected. It is at times difficult to distinguish between the definite result of the treatment and a possibly psychological alteration which seems to play a very definite part. In the eight cases showing moderate and marked improvement, however, the result is definitely beyond question. In one child (Case 7) there has been a practically complete functional cure. In Case 3, the improvement is less complete but no less striking, as before treatment he was unable to turn over in bed or lift anything, while after treatment he was able to sit erect and to manipulate his wheel chair. Case 4 was also converted from a bed case to a chair, while, in Case 12, all observers agreed that the gait and muscle tone were improved.

The results to date in this series bear out the conclusions of Kure and Okinaka that in early cases a functional cure may be obtained in cases of progressive muscular dystrophy, a previously hopeless condition. In later cases some amelioration of symptoms can be obtained.

CONCLUSIONS

From the data presented we feel justified in reaching the following definite conclusions.

1. Progressive pseudohypertrophic muscular dystrophy is a more common syndrome than is commonly appreciated, having an incidence of approximately six per 100,000 total population in the New England states.
2. The disease is wide-spread, occurring throughout the civilized world.
3. The recently acquired knowledge of the double enervation of skeletal muscles has opened up a new conception of the pathology and pathogenesis of the disease.
4. Contrary to the original conception that the disease is primarily of the muscle substance, there is evidence to believe that there is a primary lesion of the mid-brain, affecting the autonomic nervous system.
5. The endocrine disturbances frequently reported are not an essential part of the disease, but are due to derangement of the autonomic enervation of these glands.
6. The endocrine dysfunctions are seen most commonly in the less typical cases.
7. The complicating central nervous system disorders are due to a more extensive involvement in the primary lesion.
8. In some cases there is suggestive evidence that the primary lesion may be caused by an acute infection. In the majority of cases, however, there is no direct evidence of this.
9. The natural course of the disease is fairly constant,—with onset of symptoms appearing between the ages of two and four, and progressing to inability to walk at between eight and twelve. In four to six years more the use of the arms is lost, and death from an intercurrent infection occurs after another two to three years, at an age of from fifteen to twenty.
10. Previous therapeutic measures have been almost uniformly without effect.
11. Hyperdermic injections of adrenalin and pilocarpin have been of symptomatic temporary benefit in every case.
12. In the extremely advanced cases this improvement has been of more scientific interest than of practical value.
13. In hopelessly bed-ridden cases definite increase of independence by the improved use of the arms has been obtained.
14. In a comparatively early case a symptomatic and functional recovery has been obtained.

15. No claim can be made for the permanency of the improvement. It is our purpose to keep the cases under observation, and report subsequently on their ultimate outcome.

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RELATION OF THE SYMPATHETIC NERVOUS SYSTEM TO HYPERTROPHIC ARTHRITIS

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The following report is submitted as a provoker of thought and observation in the profession. The significance of the observation I do not know.

S. G., aged sixty-one, came complaining of intermittent claudication and paraesthesia of the arms; onset about two months ago, progressive in character. All the objective signs of an early case of thrombo-angiitis obliterans were evident. X-rays, for possible arterial sclerotic changes, were negative. Blood picture was perfectly normal. Urine examination revealed a mild nephritis with phthalein test of 39.9 in two hours. Operation on the left lumbar sympathetic was performed May 29, 1931. A typical Royle approach to the lumbar sympathetic chain was used, revealing the aorta and psoas muscle. On palpation it was obvious that there was an extensive arthritic process involving the bodies of the fourth and fifth lumbar and the third and fourth lumbar vertebrae. Great difficulty was experienced in securing the chain of sympathetic ganglia because of this markedly hypertrophic arthritis. When finally secured, it was observed that the sympathetic trunk was involved in the mass of tissue surrounding the hypertrophic process between the fourth and fifth lumbar vertebrae. With great difficulty it was dissected free; it seemed to be contracted in this area as compared with the trunk immediately above. Postoperatively the left leg was distinctly pinker and warmer than the unoperated right leg.

Certain interesting questions arise in our minds as we look at this problem from the orthopaedic standpoint: (1) This is the only instance in which this observation has been made by either myself or Dr. Vernon Thompson in something like 300 operations on the sympathetic system. However, in all fairness, it must be said that the majority of these operations were done on children and persons in early life. (2) It suggests no etiology of thrombo-angiitis obliterans. (3) Since the sympathetic is both afferent and efferent in character, it may be that some of our chronic painful backs, in which we have only been able to find a hypertrophic arthritis, are experiencing pain from involvement of the sympathetic trunk in the hypertrophic process. (4) It might also have some definite bearing on sciatic pain. It would seem advisable in all these cases to make note of sympathetic phenomena,—such as sweating, size of pulse, blanching on elevation and cyanosis on dependency.

We would suggest that no autopsy is complete until the condition of the sympathetics in respect to the hypertrophic process along the spine has been investigated. It would seem quite plausible, in certain cases of back and leg pain associated with sympathetic phenomena and hypertrophic arthritis, to perform properly placed sympathetic rami truncectomies. The subject suggests further observation and study.

FUSION OF THE KNEE JOINT IN CASES OF CHARCOT'S DISEASE

Report of Four Cases*

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The instability in Charcot's disease of the knee joint is so disabling as frequently to necessitate the use of support, for which a brace is of but little use. It has seemed worth while to attempt to arrest the destructive process and stabilize the knee joint by operative fusion. In the four cases herewith presented the disease had progressed to moderate destruction of the articular surfaces in two, and to a marked degree in the other two. The instability of the joints presented a serious handicap to each patient.

HISTORY OF CASES

Case 1. J. W. J., No. 114103. A fifty-one year old negro applied to the New York Orthopaedic Dispensary, November 10, 1928, complaining of a swollen left knee joint which was but slightly painful. He had had rheumatism for many years, but his present trouble he dated from one year prior to admission. The left knee was markedly swollen with a good deal of oedema, and it was held flexed twenty degrees, with limited range of motion, — from 135 degrees to 160 degrees. There was considerable lateral motion. The patient showed a slight Rhomberg. Ankle jerks and knee jerks were not obtained. Sensation was decreased in the legs. The pupils were irregular and reacted sluggishly to light and accommodation. Roentgenograph (See Figure 1) showed marked atrophic loss of substance of the internal table of the tibial head, condensation and disorganization of the joint, massive effusion, and detritus widely distributed in the effusion. Periosteal calcification of the femur was noted. The blood Wassermann was four plus.

The patient was admitted to Sea View Hospital November 19, 1928, and a fusion of the left knee joint was done on December 19, 1928, under spinal anaesthesia. The articular cartilage and cruciate ligaments were gone. There were great masses of bony detritus. The bone on the articular surfaces was ivory hard.

The specimens included spinal fluid which showed a two-plus Wassermann reaction, joint fluid which showed a four-plus Wassermann reaction and was negative for tuberculosis by smear and culture, and tissue excised from the knee joint. The report on excised tissue from the laboratory of the New York Orthopaedic Dispensary and Hospital showed chronic inflammation with no evidence of tuberculosis. From the tissue excised at operation a diagnosis of chronic hyperplastic arthritis, probably syphilitic, was made in the laboratory at Sea View Hospital.

On January 4, 1929, the patient developed a marked thrombophlebitis of the right leg which subsided after two weeks with elevation of the leg, bandaging, and ice bags. On February 13, 1929, it was noted that the fusion of the joint was progressing satisfactorily. Spica was removed and a circular plaster-of-Paris splint was applied from toes to upper thigh. Antiluetic treatment was administered at intervals over a period of eight months. The blood Wassermann was four plus on April 22, 1929.

*From the clinic of the New York Orthopaedic Dispensary and Hospital and Seaview Hospital, New York City.

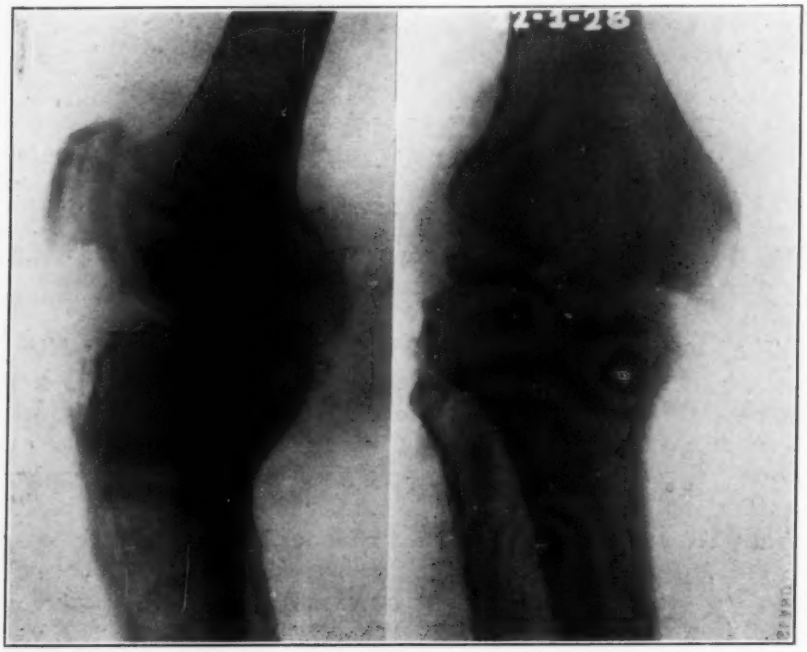

FIG. 1

Case 1. Preoperative roentgenograms of left knee.

FIG. 2

Case 1. Postoperative roentgenograms of fused left knee.

The knee was solidly fused six months after operation. All support was left off and the patient was allowed to walk. He was discharged from the hospital on October 16, 1929, walking well and in good general condition. Postoperative roentgenograph (See Figure 2) showed solid bony fusion between the tibia and femur. On February 28, 1930, the patient was walking well with the knee solidly fused.

CASE 2. No. 45900. A widow, forty-one years old, was admitted to the outpatient department of the New York Orthopaedic Hospital, May 9, 1921, with swelling and instability of her left knee following a fall two years before admission. Examination showed marked swelling of the left knee and leg, crepitus on movement, and instability of the knee. X-rays revealed a very extensive swelling of the left knee with bone detritus. There was slight destruction of the head of the tibia together with marked bone production of the tibia, fibula, and patella (See Figures 3-A and 3-B). The blood Wassermann was four plus. A brace was ordered and the patient was referred to the Vanderbilt Clinic for antisyphilitic treatment, which was continued for one year. The disintegration of the knee progressed and walking became increasingly difficult even with the brace.

In October 1928, it was decided to attempt fusion of the joint and the patient was admitted to the New York Orthopaedic Hospital. The left knee was very boggy and swollen. Motion was present from full flexion to 170 degrees of extension and there was a knock-knee deformity of forty-five degrees with marked lateral instability of the joint. Blood Wassermann was negative.

A knee-fusion operation was performed on October 17, 1928. The articular surfaces of the femur and tibia were devoid of cartilage, but were smooth and eburnated. The outer condyle of the tibia was absent and was represented by a large, oval, loose piece of bone. There were no tibial spines and no vestige of the cruciate ligaments. A small strand of semilunar cartilage was found on each side. A great many pieces of bone, round or oval in shape and varying in size from a few millimeters to five centimeters in

FIG. 3-A

FIG. 3-B

Case 2. Preoperative roentgenograms of left knee.

FIG. 4

Case 2. Photograph of loose bodies removed from knee joint.

diameter, some entirely loose and others attached to the capsule, were found in the joint cavity. These appeared to be covered by cartilage. Most of those in the anterior part of the joint were removed but those in the posterior compartment were not (See Figure 4). The bone of the femur and tibia was quite dense and hard at the surface but was more spongy at a depth of one or two centimeters. A large cystic cavity, about five centimeters in diameter, and filled with gelatinous material, was found in the epiphysis of the femur at a depth of two centimeters. The patella was very large and represented a ring of osteophytes around its margin. The joint was arthrodesed by a modification of the Hibbs method.

The patient was transferred to the Country Branch of the Hospital where she remained until March 10, 1929, four and one-half months after operation. Bony union seemed probable at the time but was not certain. She wore a plaster cast until April 3, 1929, five and one-half months after operation, at which time bony union was present. On April 30, 1930, one and one-half years after operation, her arthrodesis was solid with the knee in five degrees' flexion and fifteen degrees' knock-knee. There was shortening of one and one-quarter inches. The patient walked with a slight limp due to the shortening but had no pain or disability (See Figures 5-A and 5-B).

CASE 3. J. E., No. 121507. A laborer, forty-one years old, came to the New York Orthopaedic Hospital on July 31, 1929, because of swelling of his right knee following an injury from a fall one week before. Four years previously he fell, injuring the same joint, and was in bed one week. He had gonorrhea twenty years ago but denied having had syphilis. Before admission he had been seen at the Vanderbilt Clinic where a blood Wassermann was negative. His pupils were small and irregular and reacted very sluggishly to light. Patellar reflexes were absent. The right knee was markedly swollen, especially in the region of the patella which seemed greatly enlarged. Motion was limited from 160 degrees to sixty degrees and was painful. The left knee was not swollen but there was marked crepitus on motion and a loose body could be palpated below the patella. X-ray showed arthritic lipping and several loose bodies in the left knee, and an old fracture of the right patella with marked separation of the fragments which were united by a large irregular mass of bone (See Figures 6-A and 6-B).

The patient was admitted to the hospital for exploration of the right knee, but while in the ward a Wassermann test was reported as four plus and he was discharged on September 26, 1929, for further antisyphilitic treatment. On October 16 he reported that a few days previously his right knee had given way and that it was now more bowed.

FIG. 5-A

FIG. 5-B

Case 2. Postoperative roentgenograms of left knee fused.

FIG. 6-A

FIG. 6-B

Case 3. Preoperative roentgenograms of right knee.

X-ray showed a fracture of the inner tuberosity of the tibia. He was again admitted to the hospital and on November 25, 1929, a knee-fusion operation was done. The bone of the patella and tibia was found to be very hard and the synovial membrane was greatly thickened and oedematous. The inner tuberosity of the tibia was depressed. Incision healed normally and he was discharged from the hospital in a plaster cast on April 13, five months after operation, at which time the knee was firmly fused (See Figure 7). He then went to work as a laborer. On October 21, 1930, ten months after operation, his right leg gave way while he was stepping off a street car. He was brought to the hospital with a transverse fracture at the junction of the upper and middle thirds of the femur, from which he suffered practically no pain. It was reduced and treated in a Thomas splint. He is now walking without support, June 1, 1931.

Case 4. N. P. F., No. 113459. A widower fifty-three years old was first seen in the out-patient department of the New York Orthopaedic Dispensary and Hospital on September 9, 1928. His chief complaint was pain and swelling in the left knee which began four years previously after a slight bump. This was treated by incision and drainage. He had contracted syphilis twenty years before admission and was treated with salvarsan. The left knee was greatly enlarged, apparently from bony hypertrophy as well as swelling of the soft parts. Motion was limited from 150 degrees to ninety degrees and was slightly painful. The right knee was also swollen and motion was limited from 110 degrees to seventy degrees. There was fifteen degrees of knock-knee

Fig. 7

Case 3. Postoperative roentgenogram of right knee showing fusion.

deformity. The left fifth toe was missing and there was an ulcer at the base of the third toe. X-ray showed massive osteophytic production, bone detritus, and loss of substance. There were marked osteophytic growths in the right knee, also. The patient was referred to the Vanderbilt Clinic for antiluetic treatment. In February, 1929, it was reported that his blood Wassermann was negative and the spinal fluid four plus, but that it was considered that he was ready for operation. He was then admitted to the New York Orthopaedic Hospital and a left knee fusion was done on February 20, 1929. A quantity of brown, purulent material escaped when the capsule was opened. The joint space was filled with granulation tissue and no evidence of cruciate ligaments or menisci was found. About one-third of the medial condyle of the femur was gone, but no loose bodies were encountered. X-rays taken after the operation showed good contact and alignment. The temperature rose to 104.2 degrees on the fourth day after operation and subsided after an hematoma was evacuated. The patient was transferred to the Country Branch of the Hospital and remained there until January 5, 1930. The wound broke down, numerous sinuses formed, and there was still slight motion between the femur and tibia at the time of discharge. He was admitted to the Kings County Hospital in February 1930.

Sections of the tissue removed at operation showed chronic inflammation and foreign-body reaction around bits of necrotic bone.

SUMMARY

In the four cases here presented in which the operation was done, solid bony fusion resulted in three and the results were very satisfactory, *i.e.*, the patients were able to walk without a brace or other support and had no instability in the knee. It is interesting also to note that firm union was present in one at four months, in another at five and one-half months, and in the third at six months. This compares very favorably with cases in which the fusion operation was done for other conditions, — such as tuberculosis; stabilization of the knee in poliomyelitis, etc. Not a little doubt was felt as to the possibility of obtaining bony fusion in a Charcot joint. Although this series is too small to justify any general conclusions, the results are sufficiently encouraging to warrant trying the operation in other selected cases.

The fourth case, in which fusion did not take place and in which the wound broke down with the formation of sinuses, undoubtedly was too far advanced and should not have been operated upon. The patient's general condition was poor and, in addition to involvement of both knees, there was partial destruction of the metatarsal bones of one foot and a trophic ulcer.

The technique used in these operations was that described by Hibbs[1] for stabilization of the knee in poliomyelitis, and afterwards employed for any condition in which arthrodesis of the knee is indicated, modified somewhat to meet the peculiar circumstances of each case. Weight-bearing in plaster was allowed at the end of six to eight weeks.

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DISPLACEMENT OF THE UPPER EPIPHYSIS OF THE FEMUR (ADOLESCENT COXA VARA) TREATED BY CLOSED REDUCTION*

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The relationship of the head to the neck of the femur in adolescent coxa vara is a definite and accepted fact. In this disease the capital epiphysis moves from its normal site to a position that is internal, downward, and backward. The neck of the femur suffers a converse displacement which is upward, inward, and forward. It is also generally accepted that the results by closed manipulation have been poor. Key[1] reports thirteen cases treated in this manner, all with unsatisfactory results. Wilson[2] also is very skeptical as to the value of manipulation. Key goes so far as to say that the cases which were not treated at all had a greater range of motion and were more comfortable than those treated by manipulation.

Thus in the two most authoritative articles on adolescent coxa vara (Key and Wilson), both authors agree that closed reduction has not only not benefited the patients but has actually made them worse.

It has heretofore been the practice to treat these cases like fractures of the neck of the femur,—to reduce them according to the method of Royal Whitman and then immobilize them in a long plaster spica in a position of *full* extension, slight internal rotation, and the physiological limit of abduction. In fractures of the neck of the femur, however, the conditions found are not the same as those in adolescent coxa vara. In fractures of the neck the proximal fragment is fixed in its *normal* position within the acetabulum. The distal fragment is displaced upward, outward and *posterior*. In adolescent coxa vara the proximal fragment is displaced internally, backward, and downward. The distal fragment is also displaced upward and outward but is *anterior* instead of posterior. Therefore, when these cases were treated according to the Whitman procedure, the anatomical results were far from gratifying. Analysis of the roentgenograms revealed that the epiphyses were still in varying degrees of *backward rotation*.

This obvious fact has apparently not been duly stressed and it may account for the poor results of the manipulative method.

ROENTGENOLOGIC FINDINGS

The most important factor to be considered is the roentgenologic picture. Normally, in the gross, the epiphysis looks like a bisected sphere. The round surface articulates with the acetabulum, whereas the flat surface

*From the Services of Dr. Herman C. Frauenthal and Dr. Leo Mayer.

FIG. 1-A
Normal

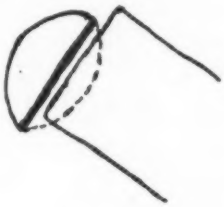

FIG. 1-B
Early changes

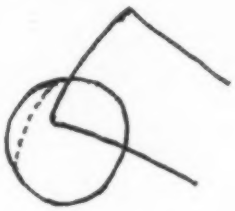

FIG. 1-C
Late changes

is attached to the neck of the femur. In a roentgenogram the head has, approximately, the appearance of a bisected circle. This fits upon the neck and, if anything, is slightly lateral to it. The epiphyseal or flat surface is not visible except as a rather broad line where it is attached to the epiphyseal surface of the neck of the femur.

In this disease the pathological process produces a laxity in the attachment of the epiphysis with the neck with the attendant results: the head begins to move medially and then backward and downward.

In the very early cases there may be only a slight broadening of the epiphyseal line; in the later cases the picture is entirely different. It is evident that the epiphyseal surface of the head is presenting itself, first, as an ellipse and later as a full circle. At the same time it is also seen that the epiphysis itself no more resembles a bisected circle: its bisected diameter is becoming shorter so that in time it may resemble a bisected narrow ellipse. These changes take place in inverse ratio to each other: the larger the presenting epiphyseal surface, the narrower the height of the epiphysis proper. (See Figures 1-A, 1-B, and 1-C.)

CONSIDERATIONS PRELIMINARY TO THE TREATMENT

It is a conceded fact that fractures heal more readily and quickly when the reduction is anatomically perfect.

The *best* and *only* principle to be used in the treatment of *any* fracture is: *Determine* the position of the *proximal fragment* and then manipulate the distal fragment into that position. With this principle in mind it was decided to try and reduce the cases of adolescent coxa vara by a modification of the orthodox Whitman procedure.

When the displacement is only a medial one of the proximal fragment, internal rotation and forcible abduction will reduce the displacement and then the limb may be immobilized in a plaster spica in the usual position of full extension, abduction, and internal rotation.

But when, in addition, there is a backward and downward rotation, this manipulation will not give anatomical replacement. Assuming that the plane of the epiphyseal surface of the neck is horizontal, that of the head may vary from a very acute angle (five degrees) to almost ninety degrees. (See Figures 2-A, 2-B, and 2-C.)

FIG. 2-A

FIG. 2-B

FIG. 2-C

In order to bring these surfaces together the lower fragment must be brought upward by flexing the thigh, the amount varying according to the angle between the epiphyseal surfaces of the proximal and distal fragments. (See Figures 3-A, 3-B, and 3-C.)

FIG. 3-A

FIG. 3-B

FIG. 3-C

INDICATIONS FOR CLOSED REDUCTION

Only the early cases should be so treated. These early cases may be divided into two groups:

A. This group includes those where the patients complain of pain in the hip, inability to walk the usual distances, and limp. There is limitation of motion, especially of internal rotation and abduction. Shortening of the limb is usually present. These patients are of the hypopituitary or "Fröhlich" type near or in the second decade of life. Roentgenograms of these patients show definite changes; the normal relationship between the head and neck has been disturbed; the head has been displaced medially and there is some backward and downward rotation.

B. Comprising this group are those of group *A* in whom there is the additional factor of mild trauma. This superimposed injury produces an epiphyseal separation.

CONTRA-INDICATIONS FOR CLOSED REDUCTION

A. This group includes the very early cases where the roentgenograms are either negative or show only a slight broadening of the epiphyseal line.

B. Making up this group are the chronic or late cases where there is a complete separation of the head from the neck in malposition due, *not* to a trauma, but to the progression of the disease itself.

TREATMENT

All cases should be converted into acute fractures at the epiphyseal line. Wilson states that he was unable to free the neck from the epiphysis even in the early cases. These attempts were made with the hip joint exposed. He claims that during the manipulation the epiphysis rotated with the neck. In the three cases to be reported comparatively little trouble was experienced in producing an epiphyseal separation in two of them; the third case had already been converted into an epiphyseal separation by reason of a fall.

When one remembers that the head is not firmly attached to the neck, the danger of a fracture taking place at any other site is practically zero. This fracture is accomplished by *forcible* internal and external rotation, with the hip somewhat flexed. The pelvis must be held firmly to the table in order to eliminate motion from this quarter. Only when full physiological internal and external rotation can be made, then, and then only, should the operator feel satisfied that the proximal and distal fragments are completely separated. Should it be impossible to free the fragments from each other, all further manipulations should be stopped and the case considered one for open reduction.

Steps in the Actual Reduction of the Fracture:

1. *Internal rotation*—The extremity is rotated internally so that the patella is pointing slightly inward, mild flexion being maintained all the time.

2. *Abduction*—This motion tends to overcome the medial displacement of the upper fragment (not full abduction).

3. *Flexion*—This motion is the next and most important procedure. This manoeuver brings the fractured ends of the fragments into complete apposition. While this is being done with one hand by grasping the knee, the other hand, having been placed on the anterior aspect of the upper end of the thigh proper, exerts a strong pull *downward* on the upper end of the distal fragment. The amount of flexion depends upon the degree of angulation between the head and neck; the greater the angle, the greater the flexion required for reduction.

4. *Extension*—The purpose of this motion is to endeavor to bring the head forward (anterior) as much as possible. The distal fragment is being used as a lever to overcome the backward and downward displacement of the head. This must be done very *carefully* and *slowly*. It must be remembered that when the proximal fragment is displaced posteriorly, the lower fragment also becomes displaced in an upward and anterior position. Accompanying these phenomena is a commensurate shortening of the psoas iliacus. When the limb is brought into a position of extension, tension will be brought to bear upon the contracted tendon and *displacement* of the lower fragment upward and anteriorly may easily take place. Another important fact to remember is that the head is not always free and easily movable and may itself offer mechanical interference to the motion of full

extension. With the head partially fixed in malposition, if the lower fragment is brought beyond the movable arc of the upper fragment, only one thing can happen. The lower fragment will then (instead of moving the upper with it) move alone, separating the fractured ends and, if brought into full extension (in severer cases), will slip upward and anteriorly. Therefore, keeping the limb in about five to twenty-five degrees of flexion (dependent upon the epiphyseal angle), the limb is then abducted to its fullest extent. This puts tension upon the lower part of the capsule, holding the fragments in the desired position. A long plaster spica is then applied in a position of flexion (five to twenty-five degrees), slight internal rotation, and full abduction.

If anatomical reposition has been accomplished, the roentgenograms at this time should show the normal reestablishment of the epiphyseal line.

After-treatment—Complete immobilization is maintained for a period of three months after which time the plaster is bivalved and physiotherapy is instituted, including diathermy, massage, and *active* motion. This treatment is carried out while the patient is in bed. Passive motion is strictly prohibited. Weight should not be borne by the limb at this early stage. For two weeks the bivalved spica is reapplied after each treatment. For the following two weeks the plaster is only reapplied at night. After this period a Thomas walking caliper is worn for a period varying from three to six months. Physiotherapy is continued during this period.

CASE REPORTS

CASE 1. L.F., aged eight and a half years, male. While playing, he fell and injured his left hip four months previous to his admission to the Hospital for Joint Diseases, June 6, 1930. He felt no pain the next day, but one month later he complained of pain in his left hip. Nothing was done at this time except for a little massage by the boy's mother. Still another month later the boy began to limp and the pain in his hip became worse. He tired so quickly that he could not walk more than one city block.

Physical examination revealed an obese and well developed boy of eight and a half years, perfectly comfortable, while lying in bed, with the left lower extremity held in slight external rotation; angle of greatest extension 180 degrees; angle of greatest flexion 135 degrees; internal rotation zero, external rotation twenty-five degrees, abduction thirty degrees, adduction twenty degrees. All motions at the hip were painful, however. The child walked with a marked left hip limp.

Roentgenogram (Fig. 4) shows a slight medial displacement of the head with some absorption of the neck. There is some backward rotation of the head.

Treatment. Manipulation (as outlined) and a plaster spica with the hip flexed about five degrees.

Roentgenogram (Fig. 5), taken immediately after the reduction, shows a slight overcorrection of the medial displacement of the head. The neck of the femur is in contact with about ninety per cent. of the capital epiphysis. The backward rotation of the head has been entirely overcome. Roentgenogram (Fig. 6), three months after reduction, shows that there is accurate apposition of the head and neck and that the absorption of the neck has disappeared. The condition appears to be healed.

Physical examination (four and a half months after reduction). Angle of greatest flexion ninety degrees, angle of greatest extension 180 degrees, abduction thirty-five degrees, internal rotation fifteen degrees, and external rotation thirty-five degrees, adduction normal. The limbs were equal in length.

FIG. 4

Case 1. Note the slight medial displacement of the head with some absorption of the neck. There is some backward rotation of the head.

FIG. 5

Case 1. Immediately after reduction. Note the slight overcorrection of the medial displacement of the head. There is ninety per cent. apposition of the fragments. The backward rotation of the head has been entirely overcome.

FIG. 6

Case 1. Three months after reduction, shows that there is accurate apposition of the head and neck and that the absorption of the neck has disappeared.

FIG. 7

Case 2. Note the medial displacement of the epiphysis with backward rotation as evidenced by the apparent broadening of the epiphyseal line and the diminished height of the head.

FIG. 8

Case 2. Immediately after reduction, shows a perfect alignment of the fragments.

FIG. 9

Case 2. Seven months after reduction, shows a normal head and neck.

CASE 2. J.G., aged nine years, female. In August 1929 she fell and afterwards began to limp. She has fallen several times since then and with each fall the limp has become worse. The day before admission to the hospital, December 24, 1929, she fell on her left side, and since then there has been such an increase in all her symptoms that she is barely able to get about.

Physical examination showed an obese white female nine years old. The child was unable to walk or stand because of severe pain. Length of right lower extremity twenty-seven and one-half inches, length of left lower extremity twenty-six and three-quarters inches. Inspection revealed that the limb was held in fifteen degrees external rotation. Passive motions were: internal rotation zero, external rotation five degrees, angle of greatest flexion 155 degrees, angle of greatest extension 180 degrees, abduction zero, adduction ten degrees. The patient was unable to lift the heel off the bed with the knee extended.

Roentgenogram (Fig. 7) shows absorption of the neck immediately behind the epiphyseal line. There is a medial displacement of the epiphysis with backward rotation as evidenced by the apparent broadening of the epiphyseal line and the diminished height of the head.

Treatment. Manipulation and plaster spica with hip flexed about ten degrees. Postoperative roentgenogram (Fig. 8) shows a perfect alignment of the fragments. Roentgenogram (Fig. 9), taken seven months after reduction, shows a normal head and neck. A comparison of Figure 7 and Figure 9 illustrates the pathology of the displacement and the effect of the reduction. In Figure 7 the vertical height of the capital epiphysis is much less than in Figure 9; the epiphyseal surface is visible as an ellipse before reduction, whereas after reduction it shows only as a line. The medial displacement of the head has been entirely corrected.

At this time the child walked perfectly and had normal motion at the hip. Examination of the patient ten months after reduction showed the result to be permanent.

CASE 3. F.Z., aged twelve years, female. About six months ago, in November 1929, she complained of pain in the upper right thigh for one day. There was no trauma or infectious disease immediately preceding. Until four months ago patient was well; since then there has been a dull pain in the upper third of the thigh on walking only. The pain did not radiate. A slight limp was present. At this time, December 24, 1929, she reported to the out-patient department where upon physical examination only a slight limitation of internal rotation was found. Roentgenogram (Fig. 10) taken the same day shows an apparent condensation of the epiphyseal line. There was no displacement of the epiphysis. The patient was advised to enter the hospital but refused.

She was admitted to the hospital March 2, 1930. She stated at this time that the limp became progressively worse. For the past two weeks the pain had become more intense over the right hip, becoming worse upon walking or standing or when any attempt of motion at the hip was made. Physical examination revealed a slightly obese girl twelve years old. The right lower limb was held in twenty degrees' external rotation. There appeared to be a shortening of the limb. In the region of the greater trochanter, the right was much more prominent than the left. Angle of greatest flexion was 175 degrees, angle of greatest extension 180 degrees, internal and external rotation zero, abduction zero, adduction ten degrees. There was an adduction deformity of fifteen degrees, length of right lower extremity thirty-one and one-half inches, length of left lower extremity thirty-two and one-half inches. Roentgenogram (Fig. 11) shows a marked slipping of the capital epiphysis. Three-quarters of the epiphyseal surface is seen. The head is narrower. The neck is displaced upward, outward, and anteriorly.

Treatment. To illustrate the difference between the conventional method and the author's, the limb was first manipulated according to the method of Whitman and then immobilized with the limb in abduction, internal rotation and full extension (Whitman position).

Roentgenogram (Fig. 12), taken immediately after reduction, shows an apparent absence of the head, since the neck of the femur obscures it from view. The outward displacement of the neck has been overcome, but it is now more anterior than before the

FIG. 10

Case 3. Four months previous to admission to the Hospital. There is here only a slightly apparent condensation of the epiphyseal line. There is no displacement of the epiphysis proper.

FIG. 11

Case 3. Note the marked slipping of the capital epiphysis. Three-quarters of the epiphyseal surface is seen. The head is narrower. The neck is displaced upward, outward and anteriorly. This roentgenogram was taken at the time of admission to the Hospital.

FIG. 12

Case 3. Immediately after reduction by the Whitman method. Note the apparent absence of the head of the femur. The head lies behind the neck, which is now more anterior than before the reduction.

FIG. 13

Case 3. Following reduction by the author's method. Note the normal reestablishment of the head and neck.

FIG. 14

Case 3. Three months later. The process is completely healed.

reduction. Close inspection reveals a shadow resembling a complete circle posterior to the neck. This shadow is the entire epiphyseal surface of the head.

Then the deformity was corrected by the author's method and a plaster spica applied with the hip at twenty-five degrees of flexion. Roentgenogram (Fig. 13), after this reduction, shows a normal alignment of the head and neck. Roentgenogram (Fig. 14) three months later shows a healed process.

Examination of the patient, seven months after reduction, showed the angle of greatest flexion 120 degrees, angle of greatest extension 180 degrees, internal rotation fifteen degrees, external rotation forty-five degrees, adduction ten degrees, abduction thirty-five degrees, length of both right and left lower extremities thirty-three inches. The Trendelenberg sign was negative. There was no limp.

SUMMARY AND CONCLUSIONS

In early cases of adolescent coxa vara, which show a backward and downward displacement of the head, an attempt should be made by forcible manipulation to separate the head from the neck. If this is successful, or if there has been an accidental fracture at the epiphyseal line, it is possible to secure an accurate alignment of the head with the neck, not by the Whitman procedure which has hitherto been employed (full extension combined with internal rotation and abduction of the thigh), but by internal rotation and abduction combined with *flexion* of the thigh at an angle corresponding to the degree of the posterior displacement of the head. The immobilization is also one of partial flexion (five to twenty-five degrees), wherein it differs from the Whitman position, which is one of full extension. This method of reduction and immobilization, based as it is on the accepted principles governing the treatment of all fractures, has given excellent results in the three cases reported in this paper.

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A REBALANCING OPERATION FOR PRONATED FEET

BY WILLIAM ARTHUR CLARK, A.M., M.D., F.A.C.S., PASADENA, CALIFORNIA

Many operations have been devised for flat feet. The Gleich[1] operation popularized by Lord[2] consists in oblique osteotomy of the os calcis and displacement of the inferior fragment inward and forward. Lowman[3] does an osteotomy of the scaphoid and loops the anterior tibial tendon under the scaphoid, which has the effect of shortening this tendon. Soule[4] does an arthrodesis of the astragaloscaphoid joint by means of a bone peg. Ogston[5] also does an arthrodesis of this joint after resecting the head of the astragalus. Other surgeons who do arthrodesis operations are: Hoke[6], with a peg through the scaphocuneiform joint; Miller[7], at the scaphocuneiform, and sometimes also a wedge from the neck of the astragalus; Ogilvy[8], at the astragaloscaphoid joint; Wilms[9], wedge from the head of the astragalus inserted into the calcaneocuboid joint and arthrodesis of the astragaloscaphoid; Wachter[10], multiple arthrodesis after sawing obliquely through the entire tarsus. A transplant of the extensor longus tendon into the anterior tibial tendon, after shortening the latter, is described by Roberts[11]. Stokes[12] resects a wedge from the head and neck of the astragalus. Schwartz[13] takes a wedge from the inner border of the tarsus, regardless of joints.

It will be noted that most of these operations consist of arthrodesis of one or more joints.

For the badly pronated foot, however, in which the arch is not completely down, a rebalancing of the weight-bearing structures of the tarsus, without arthrodesis, is all that is necessary. In seeking to correct any angle of deformity the logical place to make the change, from a mechanical point of view, is as near the angle of deviation as possible. In the pronated foot the angle of abduction deformity has its apex at about the junction of the astragalus and scaphoid, and the angle of valgus deformity has its apex pointing mesially at the calcaneo-astragaloid joint. The abduction is corrected by osteotomy of the neck of the astragalus and removal of a wedge near the head, after the method of Hoke. The pronation is corrected by removing a wedge-shaped piece of bone and cartilage from the inferior mesial aspect of the body of the astragalus.

The technique of the operation is as follows: The skin incision is made beginning just anterior to the external malleolus and extending distally and mesially in a curve ending about over the middle cuneiform. Dissection is done, keeping close to the bones, turning the extensor tendons mesially with the skin flap and exposing the head and neck of the astragalus. Osteotomy of the neck is done in a plane at right angles to its long axis and the head removed temporarily. This brings the subastragaloid joint into view. The crucial part of the operation is now to be done,—that is, the removal of

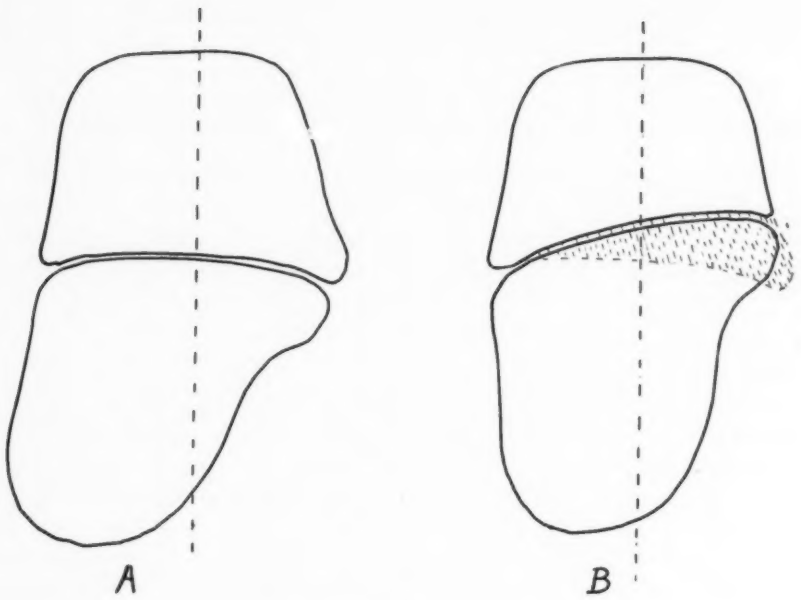

FIG. 1

A. Frontal section through left astragalus and os calcis viewed from behind, showing pronation deformity.

B. Same, after operation; the part removed is shown by shading.

a wedge from the mesial articular surface of the astragalus, where it curves over the sustentaculum tali. It is usually not possible, and, in fact, unnecessary to remove this wedge intact, but it can be peeled off in a sculptural fashion with chisel and mallet. Viewed from its mesial aspect this wedge will have a crescent shape with the points of the crescent directed downward. From one-half to two-thirds of the inferior articular cartilage of the astragalus comes off with the wedge. At its thickest part on the mesial edge it is from five to eight millimeters thick. The original contour of the curve over the sustentaculum is preserved as nearly as possible. The foot can now be manipulated into the corrected position by forced supination. This changes the position of the os calcis so that its superior articular surface tilts slightly outward, the sustentaculum being forced upward into the new sulcus made for it in the astragalus. All the articular cartilage of the os calcis being preserved, there is no subsequent ankylosis. After reshaping the head of the astragalus by removal of a mesial wedge from its neck portion, it is replaced and the wound closed.

The foot is then placed in a cast in extreme supination and adduction, this position being maintained for six weeks. Following this, the foot is kept strapped in supination for a few weeks. On beginning to walk at about eight weeks, a supinating heel is applied to the shoe and a soft leather and felt pad placed inside the shoe, to be worn for a few months until final hardening of the astragalus has taken place.

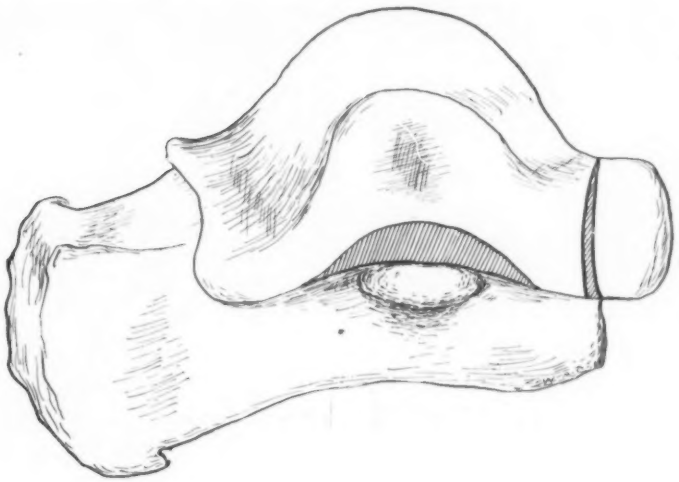

FIG. 2

Mesial view of left astragalus and os calcis. The parts to be removed are shown by the straight line shading. (Drawn from wooden models.)

CASE REPORTS

CASE 1. Girl, aged twenty-one. Left foot badly pronated. Treatment started December 8, 1925. Operation June 24, 1926, left foot only. Incision over the lateral anterior aspect of the foot as for astragalectomy. Osteotomy through neck of astragalus. Head of astragalus removed temporarily. Mesial half of the inferior articular surface of the astragalus, including wedge of bone, shaved off with chisel. The head of the astragalus was then replaced, after cutting a thin wedge from the mesial side of the neck portion to allow more adduction of the foot. Cast applied with the foot in extreme supination and adduction.

Cast discarded August 10. The foot maintained itself in good balance without pronation on weight-bearing. In May 1927, this good position was still evident and there were no subjective symptoms.

CASE 2. Boy, aged about nine. Left foot badly pronated and abducted, right moderately pronated. Both feet spastic and peroneal tendons contracted. Operation November 3, 1926. The same technique as in Case 1, with the addition of tendon lengthening of both peroneal tendons of both feet. A poor result was obtained in this case, evidently due to the general spastic condition. Case not properly selected.

CASE 3. Girl, aged ten. Scaphoids prominent. Feet badly pronated. Knocked ankles together in walking. Treatment started March 15, 1927, but as correction by conservative means looked hopeless and since the deformity was so severe, operation was advised at once, and was done on both feet April 27. The same technique as in Case 1 was carried out.

Casts were removed by May 24 and mobilization started. A month later the patient was walking with feet well supinated,—in fact, pronation was moderately limited. This case showed a most striking result. (See Figures 3 and 4.)

CASE 4. Girl, aged nineteen. Feet badly pronated and aching. Symptoms about a year in duration. Treatment started December 4, 1928. After three months the symptoms were ameliorated, but the pronation persisted.

Operation March 20, 1929. Both feet done after the same technique as in Case 1. Because of pain the extreme supination was diminished after a few days by cutting the casts. In six weeks the casts were completely removed and motion started. This

FIG. 3

Case 3. Before operation.

FIG. 4

Case 3. About three months after operation.

patient was very slow in getting back on her feet and did not walk without crutches until early in June, over two months. A year after the operation she was free from symptoms and the feet were well maintained in good balance without pronation on standing. When last seen, February 1931, she complained of fatigue in the feet, but there was no recurrence of the pronated position.

CASE 5. Boy, aged sixteen. Both feet pronated, abducted, and arches flat. Scaphoids prominent. He was said to have had infantile paralysis, but no abnormal muscle balance or weakness could be demonstrated. Had had conservative treatment for a year or more before coming to the clinic. Operation December 6, 1930, with technique as described above. When last seen, March 4, 1931, he was walking with a limp, the feet being still tender from the operation. Both feet appear to be improved in position, left better than right, as compared with photographs taken previous to operation.

SUMMARY

Out of five cases operated upon, a good result was obtained in three cases, another case being too early after operation for final judgment, but promising well so far.

Removal of a wedge from the mesial inferior aspect of the astragalus, together with osteotomy of the neck of the astragalus, permitted correction of badly pronated feet, without arthrodesis of any joints, in at least three out of five cases.

Of course, conclusions cannot be drawn from such a small number of cases, but results have been sufficiently satisfactory to justify this preliminary report and to warrant continuing with the same technique in subsequent cases.

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PERITROCHANTERIC BURSITIS

Report of a Case

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In Volume 1, Fasc. 3, 1930, of the *Acta Orthopaedica Scandinavica*, Nilsonne reports a case of calcified trochanteric bursitis upon which he had operated. His article is entitled "Tendinitis Calcificans Trochanterica". He states that his is the first operated case reported. Although this is not strictly correct, it is true that in the present century this subject has received but slight attention.

The case reported here is very similar to Nilsonne's, and is also one of rather unusual interest and findings.

Maurice A.—Jewish, aged twenty-two years, was admitted to the Hospital for the Ruptured and Crippled, First Orthopaedic Division, on December 2, 1930.

He complained of swelling over right hip, which was slightly painful, accompanied by a slight limp.

In 1928, the patient was struck over the right hip by a rug which slipped from his grasp as he was carrying it. He was only slightly injured and went about his usual work as clerk at a soda fountain. About a year later a slight pain developed in the area of the trauma, accompanied by a slight limp, and a swelling over the right hip. This condition continued to trouble him at intervals until a week previous to admission, when the pain became more severe and continuous, but he was able to continue at his work. There had been no night sweats, cough, hemoptysis, or symptoms suggestive of tuberculosis.

Fig. 1

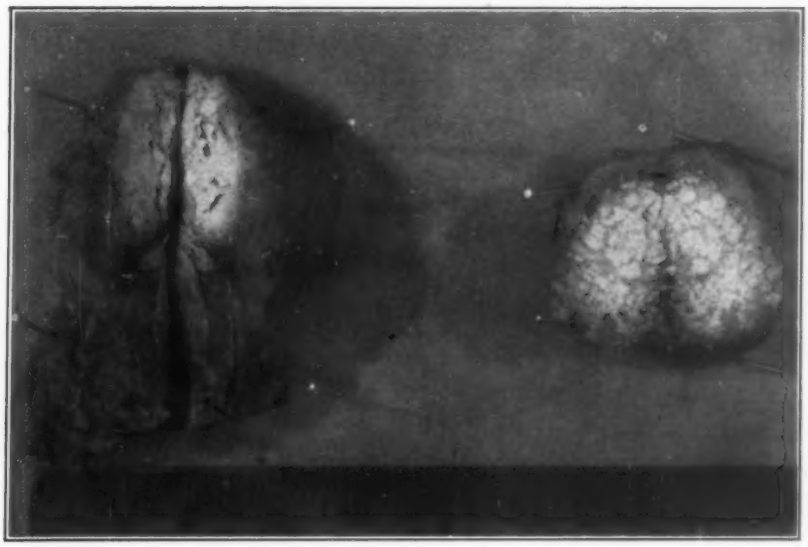

FIG. 2

There had been no intercurrent infections. He entered the hospital because of the slight pain and limp and because the swelling worried him.

Past history was essentially negative; tonsillectomy in 1929; no history of tuberculosis.

Family history was essentially negative.

Physical examination: Patient was in good general condition. Tonsils were absent. Over the right great trochanter was a hard swelling about three and one-half by five centimeters in size. It was freely movable on the deep tissues, not attached to the skin. It was slightly tender on pressure but was not acutely painful. There was no local heat or redness, no fluctuation.

The x-ray showed a triangular, granular calcareous deposit lateral to the right great trochanter. There were no changes noted in the femur (Fig. 1).

Diagnosis: Calcified peritrochanteric bursa.

Operation: December 3, 1930. Under two per cent. novocain anaesthesia, a three-inch incision was made directly over the right great trochanter. A hard, fibrous tumor, measuring about five centimeters in diameter, was found lying beneath the muscle layer, the capsule itself infiltrating the overlying muscle. It was excised and on being incised was found to be filled with whitish granular material. At a level deeper than this, was found another mass, measuring about four centimeters in diameter. It was excised and found to be lying in close apposition to the femur. The two specimens are shown in Figure 2. Closure was with plain catgut for the deep tissues and silk for the skin.

Progress:

December 6. Temperature 100.6 degrees.

December 11. Sutures removed. Wound entirely healed.

December 16. Wound healed. Patient had no pain and walked without a limp. He was discharged.

Pathological report: Sections show a sac wall made up of a mass of dense connective tissue. The cavity is filled with calcium salts. There is no evidence of bone formation.

Diagnosis: Calcified bursa.

This case is analagous to Nilsonne's in history and findings. In his specimen, however, there was seen hyalinization of cells and beginning bone formation.

A CASE OF UNUSUAL BONE DEVELOPMENT

BY EDWIN PYLE, M.D., WATERBURY, CONN.

The following case is reported because the development and growth of bones of the head and extremities of this child of five years are so unusual, resembling nothing which the author or his colleagues have ever experienced before.

The patient was brought to the writer in January 1930 by his mother because of knock-knee, which she had noticed for the past year. The child was healthy and well. He had had no previous illnesses and his dietary routine had been faultless. He had no complaints. He went to kindergarten and played about as other children of his age do.

On physical examination the child was the picture of health. He was tall for his age. His head seemed a trifle large and the frontal region was prominent. There was a quite marked knock-knee condition present, but no signs of rachitis. His chest was well developed and symmetrical. The lower radial epiphyses were slightly enlarged. The long bones of the arms and legs all felt very large and massive at their ends. There was no undue springiness to the bones. They were not tender and were apparently functioning normally except for the knock-knee and a slight limitation of about ten degrees in extension at the elbows. There was no history of a similar disturbance in the families of either the father or the mother.

The roentgenograms which are here reproduced show a peculiar development of the bones. The ends are enlarged to about two or three times the normal size. The cortex at the ends is very thin. In the shaft, however, the cortex appears to be of normal thickness and the internal structure of the medulla and the calcium content are also normal.

A double osteotomy of the condyles of the femora was performed for the correction of knock-knee. The periosteum was normal but the bone beneath it was very soft so

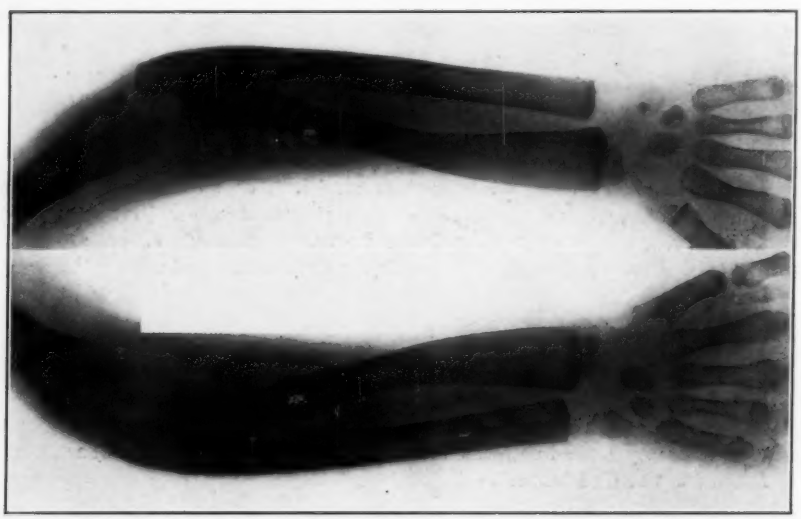

FIG. 1
Lateral view of the forearms.

FIG. 4

Anteroposterior view of legs, showing the knock-knee for which operation was performed.

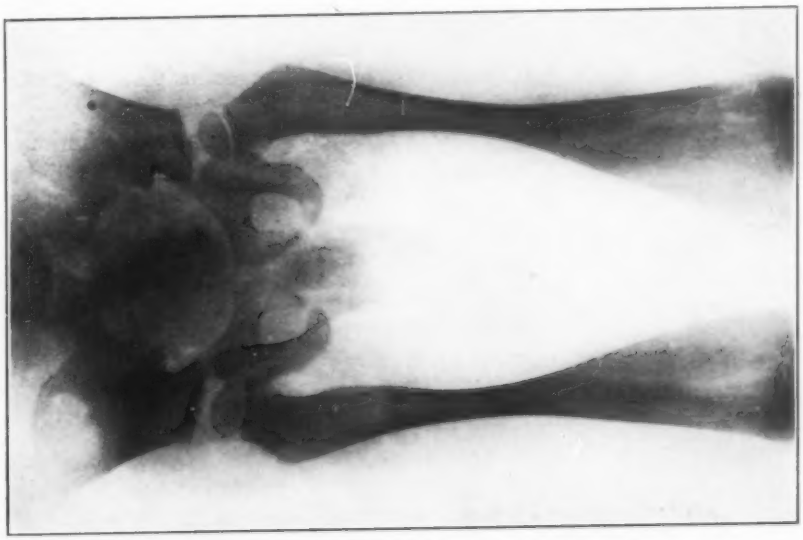

FIG. 3

Anteroposterior view of pelvis and femora. Note paddle-like shape of long bones.

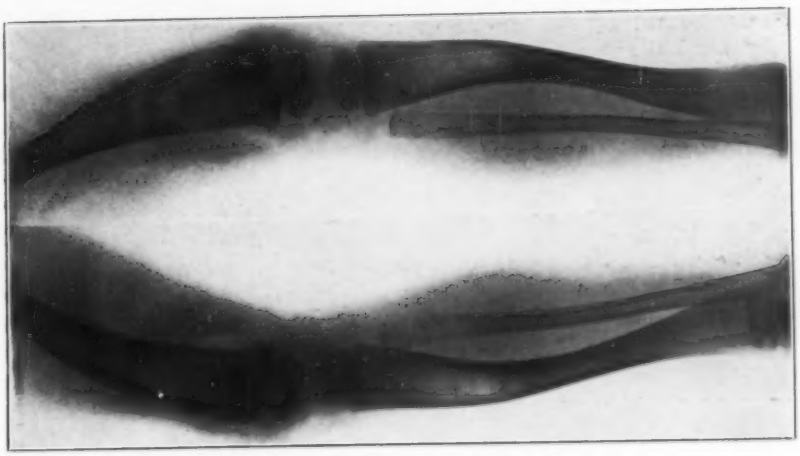

FIG. 2

Lateral view of bones of legs.

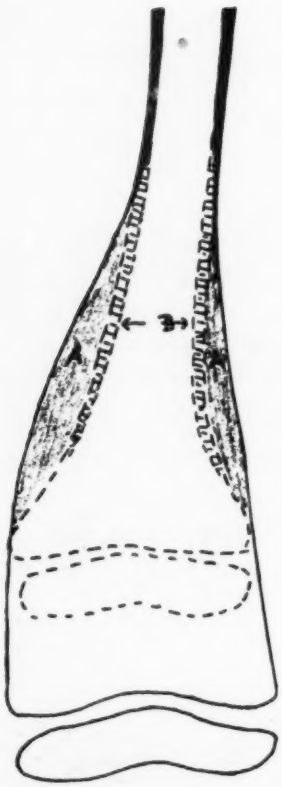

FIG. 5

As the bone grew in length it should have changed shape, in that the shaded part (*A*) should have been absorbed. At the same time the cortex should have thickened up to form the portion marked *B*.

that the chisel could be forced through the bone almost without the use of a mallet. Bleeding was not excessive. The osteotomies healed at the normal rate and callus at the end of six weeks was firm enough to warrant removal of the plaster casts. The child made a prompt recovery with excellent correction of the deformities. One year after operation a slight overcorrection of the right leg and a keloid growth in both scars were noted.

As there is apparently no literature on this subject a little speculation as to the cause of this peculiar development should be permissible. It has been suggested that the unusual growth and development of the bones was due to failure of resorption of certain parts of the bone. Most of the bone growth, especially length, takes place at the metaphyseal (shaft) side of the epiphysis. As the bones grow in length a resorption of part of the growing end is necessary for the formation of the new elongating shaft (See Figure 5). Apparently in this child there was no resorption, so that layer after layer of bone was applied to the growing ends without any morphologic changes taking place in the previously formed bone.

Not only did the new-growing bone fail to change its shape by resorption, but it failed to develop a thickened cortex as well. The shape and structure of the enlarged ends of the bone under consideration are in no way unlike that seen at the shaft side of the epiphyseal line of any normal child.

FRACTURE OF THE ANTERIOR PROCESS OF THE CALCANEUS

BY FREDERICK CHRISTOPHER, M.D., EVANSTON, ILLINOIS

Assistant Professor of Surgery, Northwestern University Medical School; Surgeon Evanston Hospital

Although there is an abundant literature on fractures of the calcaneus with careful studies of crushing fractures, avulsions, etc., no mention has been found of fractures of the anterior process of the calcaneus*.

The writer has seen two cases of this type of fracture and was kindly given the x-ray of a third case by Dr. James T. Case. It is not improbable that this injury is common and deserves recognition as a definite clinical entity.

CASE 1. Mrs. O. H. W., on April 29, 1930, while descending the stairs with a forty-pound child in her arms mistook the bottom step for the floor. She caught the heel of her shoe so heavily on the edge of the bottom step as to tear it off. She at once experienced pain deep in the tarsus of her foot. The roentgenogram (Fig. 1) showed a fracture of the anterior process of the calcaneus. Four days later a plaster cast was applied and left on for twenty-six days. There was no pain on removal of the cast and after a few massage treatments the patient was pronounced completely cured.

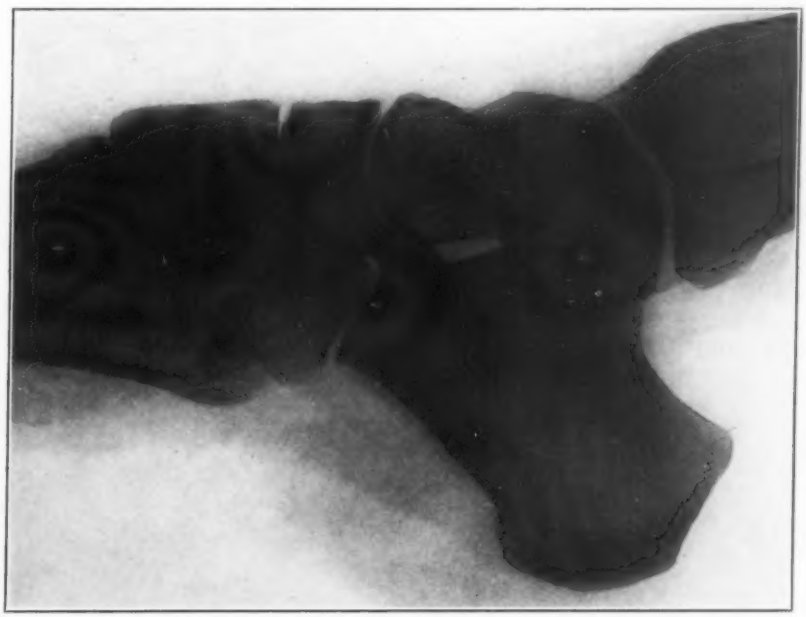

FIG. 1

*Since this paper was submitted for publication, the following article has been discovered: Dachtler, H. W.: Fractures of the Anterior Superior Portion of the Os Calcis due to Indirect Violence. Am. J. Roentgenol., XXV, 629, May 1931.

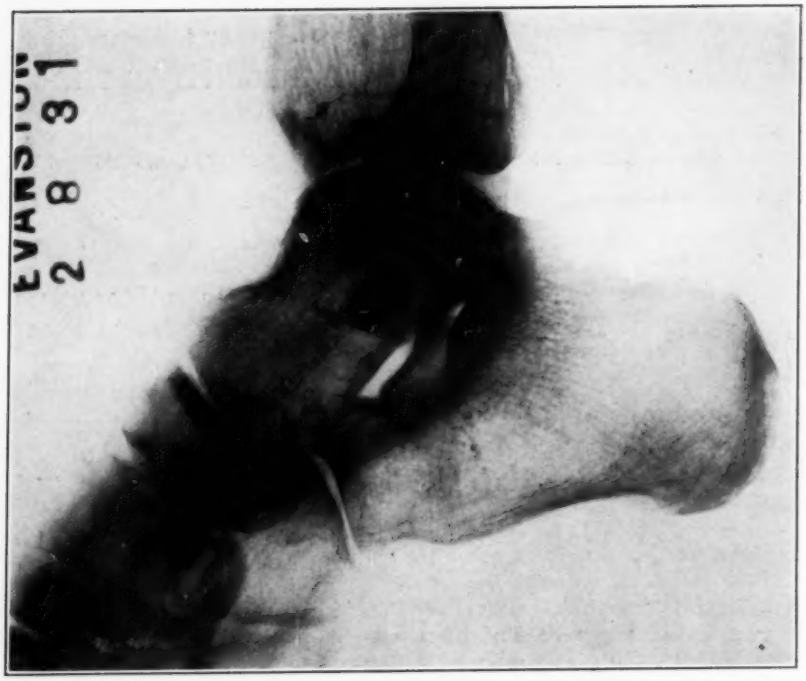

FIG. 2

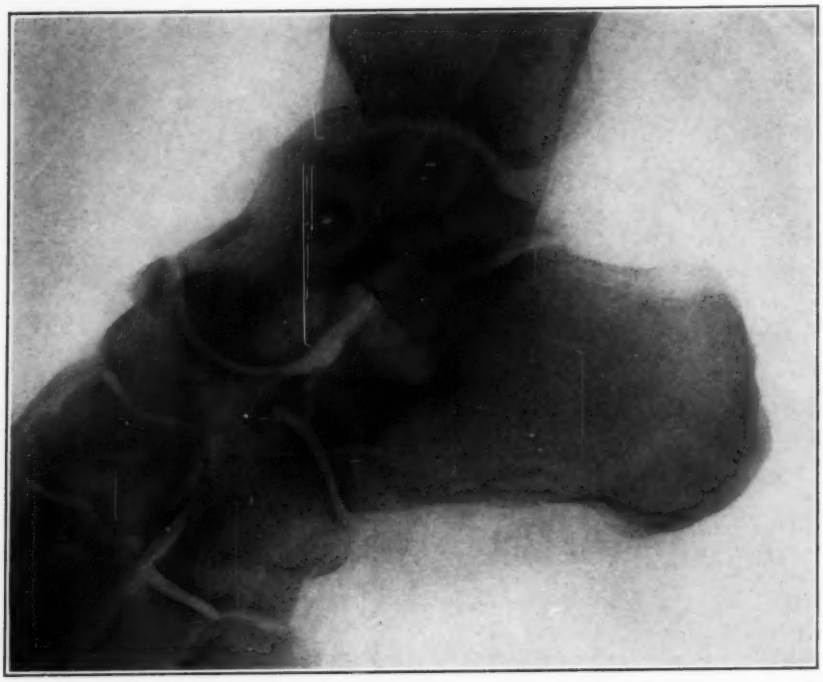

FIG. 3

CASE 2. On February 9, 1931, Mrs. G. H. G. was in an automobile accident and through some unknown mechanism injured her ankle. There was pain deep in the tarsus with and without weight-bearing. The roentgenogram (Fig. 2) showed a fracture of the anterior process of the calcaneus. Inasmuch as the fracture was slight, the ankle was not immobilized but the patient was permitted to go about on crutches. At the end of about two weeks weight-bearing was tolerated and the patient made a satisfactory recovery.

CASE 3. (Courtesy of Dr. R. C. Aiken, Blue Island, Illinois and Dr. James T. Case.) On November 23, 1929, Mrs. A. D., while carrying a child down the stairs, caught her heel on the edge of a step. There was considerable pain and the roentgenogram (Fig. 3) showed a fracture of the anterior process of the calcaneus. The ankle was strapped with adhesive and the patient was put on crutches for two and one-half weeks. The recovery was slow and the patient still has some pain a year and a half after the accident.

SUMMARY

Three cases of fracture of the anterior process of the calcaneus are reported.

The injury is thought to be common but is believed to be hitherto undescribed.*

The injury is probably caused by forcible plantar-flexion of the foot.

The treatment is immobilization in a circular plaster cast for three or four weeks followed by physiotherapy.

*Since this paper was submitted for publication, the following article has been discovered: Dachtler, H. W.: Fractures of the Anterior Superior Portion of the Os Calcis due to Indirect Violence. Am. J. Roentgenol., XXV, 629, May 1931.

A MODIFIED PLASTER-KNIFE BLADE

BY JESSE B. GRIFFITH, M.D., PITTSBURGH, PENNSYLVANIA

In all plaster knives, the sharp point of the blade is the most distal point (Fig. 1). In the case of sudden penetration through the cast, the knife point continues on through the skin and the tendency is for it to extend the incision through the normal cutting arc even though the operator knows that the knife has penetrated the skin and attempts to stop it (Fig. 2). The only way to stop the cutting action would be to instantly withdraw the knife vertically, along the radius of the cutting arc. It is practically impossible to do this because the forearm muscles are powerfully set to continue the motion along the cutting arc and cannot be immediately arrested and reversed in direction.

It is to obviate this difficulty that we have suggested that the most distal point shall be the smooth, rounded protrusion of the back of the blade and that it shall recede proximally toward the sharp side of the blade at an angle of about twenty-five degrees, and there form the sharp cutting point as shown in Figure 3. It is obvious that any knife blade can be changed

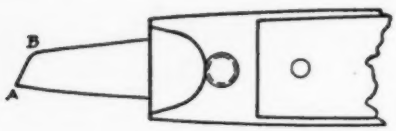

FIG. 1

Usual type of blade. *A*. Sharp distal point. *B*. Dull proximal back.

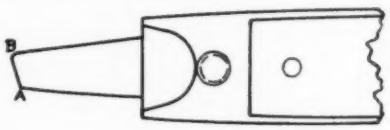

FIG. 3

Modified blade. *A*. Sharp proximal point. *B*. Dull distal protrusion.

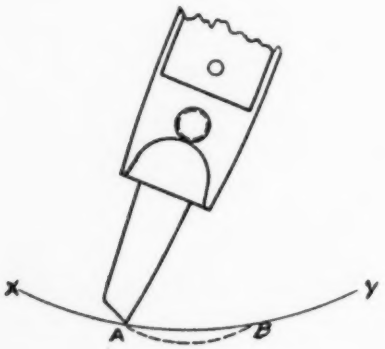

FIG. 2

A-B. Arc of motion below normal cutting arc *X-Y*, after sudden penetration with usual type of blade.

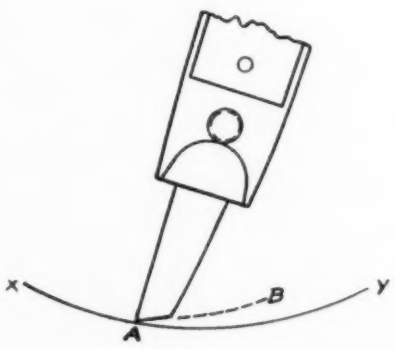

FIG. 4

A-B. Arc of motion above normal cutting arc *X-Y*, after sudden penetration with modified blade.

to this shape by merely grinding off the protruding sharp point.

In case of sudden penetration of the cast with a blade of this shape, the dull distal portion follows through immediately and tends to push the skin away. Sudden acceleration of the speed in any part of the cutting arc tends to bring the dull distal part of the blade deeper into the cut and so elevate the sharp point, making it harmless (Fig. 4). When the cast is cut nearly through, the dull end of the blade can be pushed against the padding or skin, forcing it out of the way so the sharp edge can cut the thin remaining layer of the cast without danger (Fig. 5).

Operators accustomed to using the old knives have no difficulty in using the modified blade.

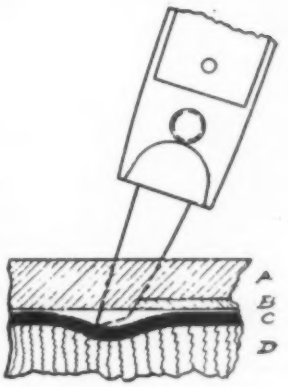

FIG. 5

A. Plaster cast. *B*. Uncut portion of cast. *C*. Protective padding. *D*. Body of patient.

UNUSUAL FRACTURES OF THE CAPITULUM HUMERI AND THE CAPITULUM RADII

BY HENRY MILCH, M.D., F.A.C.S., NEW YORK, N. Y.

Fractures of the head of the radius are almost of commonplace occurrence. Fractures of the capitulum humeri have recently received more extended consideration than has been accorded them in the past. But neither the author nor any of his colleagues recalls having seen described a case in which both of these bones were involved in the manner presented by the cases herewith reported.

K. F., female, aged thirty-six, was seen on July 3, 1930, with a history of having fallen on her extended right elbow three weeks previously. She complained of pain and limitation of motion in her right elbow. She was treated by her physician for a fracture of the head of the radius. The elbow was placed in the Jones position and after the lapse of three weeks the patient was discharged with the advice to begin using her arm.

When seen by the writer, there was practically no motion in the elbow, either of pronation, supination, flexion, or extension. There was still marked tenderness over the external condyle, as well as over the head of the radius. A tentative diagnosis of fracture of the head of the radius was made and an x-ray was ordered (Fig. 1). The x-ray showed a definite fracture of the head of the radius with a peculiar crescentic shadow projecting downward from the humerus and reaching across toward the head of the radius. This shadow could not at that time be definitely interpreted, but it was felt that exploration of the elbow would be justified.

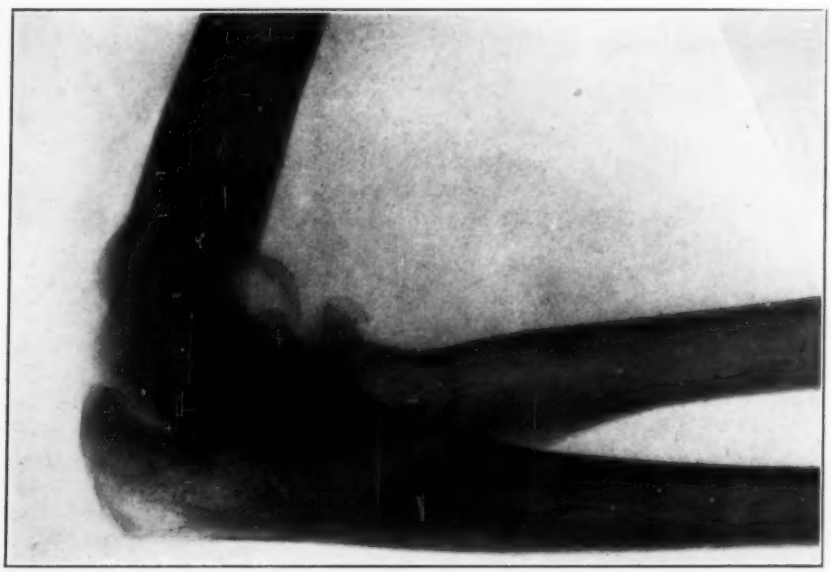

FIG. 1

FIG. 2

At open operation the following day the head of the radius was amputated, and the piece of bone seen on the x-ray picture was easily cut away from its attachment to the lower end of the humerus. Exploration of the wound disclosed that the crescentic portion of bone was actually the lateral half of the capitulum humeri. The rest of the articular surface of the capitulum was normal. When the specimen removed was examined, the situation was entirely clarified (Fig. 2). The head of the radius was found fractured into three portions. The first line of fracture, being from side to side, divided the head of the radius into an anterior and a posterior fragment. The posterior fragment was split into two smaller fragments by a fracture line running anteroposteriorly. In this fracture line, the fragment of the capitulum humeri was found inserted and firmly united. The anterior fragment was found loose. From its fixation between the two united posterior fragments of the head of the radius, and its attachment above to the capitulum humeri, the condylar fragment acted as a bone bridge between the humerus and the radius. Thus this patient had performed for herself a really quite satisfactory arthrodesis of the elbow joint with complete elimination of motion. Upon removal of the head of the radius with the attached fragment of the capitulum humeri, the complete range of normal motion was immediately restored. The patient made an uneventful recovery, and four weeks later gleefully demonstrated a perfectly normal arm.

Doubtless the fragment of the capitulum humeri became wedged between the two posterior fragments of the head of the radius subsequent to the injury, as a result of flexion of the forearm. While it must be considered as a coincidence of the most extreme rarity that the plane of the humeral fragment should by chance coincide with the plane of fracture of the posterior radial fragments, it seems as if more than mere coincidence must be invoked to explain the appearance of this same type of fracture in a second case seen recently.

C. J., male, aged twenty-six, was seen on December 17, 1930, with a history of having injured himself two weeks previously. While working on a ladder he had slipped and fallen one story to a porch. Attempting to arise, while in a semiconscious state, he had fallen another story. He does not remember how he fell, but states he was picked up in an unconscious condition and taken to a hospital. The following day he regained consciousness, and a day or two later noticed pain, swelling, ecchymosis, and disability in the right elbow. X-ray photographs showed a fracture of the elbow for which the forearm was put into the Jones position. Eight days after his admission, the patient noticed that the elbow was becoming progressively more painful and stiff. He consequently went to his physician who referred him for examination.

The right elbow was markedly swollen and was held at right angles. Extension beyond this point was impossible, though the patient could flex the forearm to about forty-five degrees. Pronation was somewhat limited. The wrist and shoulder were normal. There was definite tenderness over both the head of the radius and the lower part of the external condyle of the right humerus. The x-ray (Fig. 3) showed a fracture of the antero-external portion of the head of the radius, and a crescentic shadow lying on the anterior surface of the humerus. When the plate was examined carefully, a slight irregularity of the external condyle of the right humerus was found, and the fragment seen on the humerus was interpreted as a displaced fragment from the fracture of the external condyle.

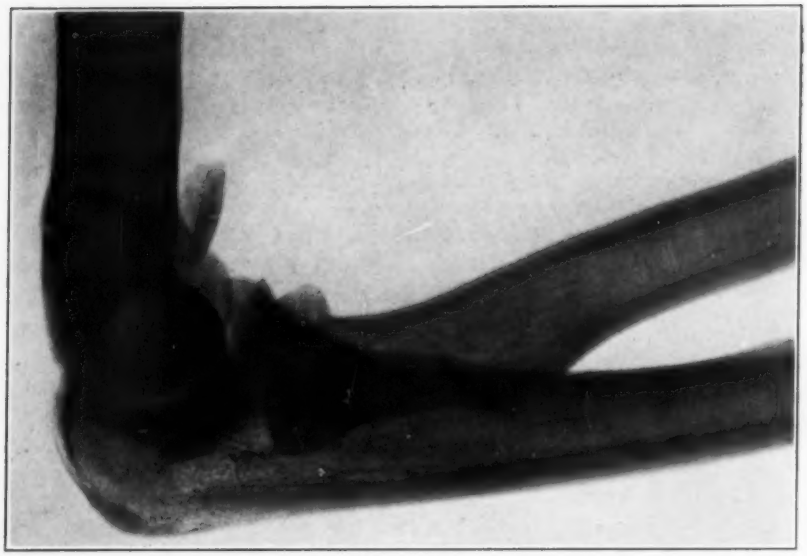

FIG. 3

On December 19, 1930, the patient was operated upon through the usual lateral incision for removal of the head of the radius. When the radius was exposed, a wedge-shaped segment of the antero-external portion of the radius was found displaced medially into the joint, which limited supination. The head of the radius was resected, and a painstaking search for the crescentic fragment previously observed on the x-ray was made. Though the fragment could not be found, the depression and defect on the anterolateral portion of the external condyle of the humerus, corresponding to the crescentic shadow seen on the film, was readily found. The cartilaginous covering of the capitulum humeri was found lying free in the joint and was removed. In the interest of the patient no further search was made for the fragment and the wound was closed. Careful examination of the head of the radius removed at operation showed that it had been removed completely. The postoperative x-ray of the right elbow showed that the crescentic fragment previously observed was still within the joint, but at a higher level and lying flat against the anterior surface of the humerus, thus definitely establishing the presence of two fractures. The postoperative convalescence was completely uneventful. The patient began to move his arm within three days of the operation, and at the end of four weeks had recovered completely normal motion of the elbow.

Clinically these cases are characterized by pain and limitation of motion in the elbow following a fall on the arm. In addition to the usual signs of fracture, these patients presented two distinct points of tenderness, one over the head of the radius and one over the external condyle of the humerus. Numerous authors have called attention to the extremely localized pain observed both in simple fracture of the head of the radius, and in simple fracture of the humeral condyle. Therefore, this double localization of tenderness may be of importance as a diagnostic sign. Roentgenologically, as well as clinically, these cases presented characteristic appearances. In addition to the usual appearance of a fracture of the head of the radius, a crescentic shadow which in both cases was at first misinterpreted by competent roentgenologists as due to a displacement of a radial fragment, was

seen lying on the anterior surface of the humerus. In the writer's experience fragments from a fractured head of the radius are seldom if ever displaced upward, and the mere appearance of a fragment of bone above the level of the radial head should suggest a fracture of the lower end of the humerus. At operation in both cases the usual type of fracture of the head of the radius was found, while the fragment from the humeral condyle appeared to be derived from the lateral aspect of the capitulum humeri. In the first case, the rest of the articular surface of the capitulum humerus was apparently uninvolved; while, in the second case, the cartilaginous covering over the inner portion of the capitulum humeri was shorn off in a manner suggesting the type of osteochondral injury seen in more marked degree in the usual fracture of the capitulum humeri.

If, for purposes of discussion, this type of fracture can be considered as a combined form of fracture of the head of the radius and fracture of the capitulum humeri, or, rather, if it may be considered as the composite result of the mechanism which operates to produce either of the other simple fractures, then their composite mechanism may permissably be employed to explain the appearance of this unusual fracture form. Though apparently these fractures, whether in single or composite form, are due to the reciprocal impinging of the capitulum humeri against the capitulum radii, yet the explanations thus far offered cannot be considered as strictly adequate, since they do not account for the more common occurrence of one form as compared with the others. Doubtless, the final explanation lies in the more careful determination of the angle of incidence of the fracturing force than we have yet or indeed may ever be able to obtain. The best we can hope for is to indicate roughly the main streams of force in an attempt to explain grossly the displacements of fragments.

It is hardly necessary to go into the mechanism of fractures of the head of the radius. In general it may be stated that fractures of the head of the radius may occur, whether the forearm be flexed or extended. In a similar manner, it has been shown that fracture of the capitulum humeri may roughly be divided into two types,—*viz*, the type characterized by anterior displacement of the fragment, which occurs with the forearm in extension; and the type characterized by posterior displacement of the fragment, which occurs with the forearm in flexion. In both of these fractures, the capitulum humeri is shorn from the humerus by the impact of the oncoming capitulum radii. In the extension type of fracture, however, the radius is directed upward parallel to the shaft of the humerus, but on a plane in front of its anterior surface, with consequent displacement of the fragment forward and upward. In the flexion type of fracture, the head of the radius is directed transversely to the axis of the shaft of the humerus and the fragment is displaced posteriorly.

In the cases above reported, the mechanism in the first one is quite obviously to be explained by the apposition of the capituli humeri and radii in the manner above suggested. In the second case, because of the fact that this patient lost consciousness, no statement as to the exact mechanism can

be made; but, from the position of the capitellar fragment, the extended position of the forearm may be predicated. Unfortunately, the author has not yet been able to observe a case in which it can be definitely established that the forearm was flexed at the time of the injury, and in which fractures of both bones with posterior displacement of the capitellar fragment occurred. Such a fracture would seem to prove definitely the mechanism here suggested, and would tend to indicate that fracture of the head of the radius, fracture of the capitulum humeri, or fracture of both these bones together were merely particular instances of a general mechanism in which variation of the force and the angle of its delivery were the determining factors.

In both of these patients operation was deemed necessary because of the marked limitation of motion. As in treatment of simple fractures of the head of the radius, operation is indicated when motion is limited. On the other hand, it must be remembered that even without limitation of motion the free fragment of the capitulum humeri may act as a foreign body, leading to intermittent interference with motion and to consequent traumatic osteochondromatosis. In such cases, it may be advisable to open the joint for the removal of the free condylar fragment early, rather than to await the development of disabling sequelae.

News Notes

Dr. Percy W. Roberts has moved his office to 115 East 61st Street, New York, N. Y.

Dr. M. Melvin Clark, formerly of Elyria, Ohio, is now associated in practice with Dr. Thomas Wheeldon, 318 West Franklin Street, Richmond, Virginia.

Observance of the Golden Anniversary of the **American Red Cross** this year marks that Society's fiftieth year of service. One of the avenues of public support is the annual Red Cross Roll Call which will be held this year from November 11 to November 26.

At the **Twenty-sixth Congress of the Deutsche Orthopädischen Gesellschaft,** held in Berlin September 14–16, Dr. Adolf Stoffel was elected the new president. The meeting next year will be held in Mannheim. A report of the Twenty-sixth Congress will appear in the next issue of *The Journal.*

Dr. Bedřich Frejka, our Foreign Editor for Czecho-Slovakia, has recently been appointed Professor of Orthopaedic Surgery of Masarykovy University at Brno.

The fourth **Lady Jones Memorial Lecture in Orthopaedic Surgery** was delivered at the Liverpool Medical Institution on May 28 by Mr. D. McCrae Aitken of London, who chose as his subject "Rest and Exercise in the Treatment of Joints".

The lecturer referred to the work of Hugh Owen Thomas who, in treating tuberculosis of the elbow, combined rest with subsequent graduated movement in securing not simply quiescence of the disease but also a small range of painless movement. The judicious combination of rest and exercise in the treatment of diseased joints is no new principle, as was shown in an old eighteenth century painting, by Paul Sandy, of gouty patients with their limbs in splints, practising bizarre capers. The same line of attack is being adopted now by Böhler in the treatment of joint injuries.

Mr. Aitken stated as a first principle that if movement of a joint is painful it is harmful, and that a painful joint should be mechanically fixed until the tenderness has subsided. Stiffness is produced not by fixation alone, but by forced movement when the joint is painful.

To secure a return of movement in a joint which has been painful, it is essential that early movements should be actively performed by the patient himself, and that the movements should be free. As far as possible, automatic reflex movements should be selected. The first movements of the lower limbs of a baby are not those of kicking, as at a football, but a rhythmical pulling and pushing, and this is the exercise to teach first in the resumption of function of a hip or knee joint. Great emphasis was laid on the fact that purposeful movements of the limbs are most easily performed at certain phases of the respiratory cycle. When a carpenter drives home a screw, the pushing external rotation movement of the upper limb is performed during expiration; whereas, when a sailor pulls on a rope, the pulling internal rotation movement is performed during in-

spiration. The respiratory relationship of the various movements of all joints has been evolved, and, when the patient is taught non-weight-bearing, unloaded active movements, great assistance has been secured by observing the normal respiratory rhythm.

The third important principle emphasized was that a joint, recovering from disease, should not be called on to bear weight until the articular surfaces have been fully recalcified and reconstructed by a long preliminary period of non-weight-bearing exercise.

The application of these principles was illustrated by x-rays and photographs of a large series of cases. In cases of osteochondritis of the hip, the flattening and broadening of the femoral head, which has been regarded as almost unavoidable, possibly may be prevented by prolonged frame immobilization, followed by physiological exercises until the epiphysis is completely regenerated before allowing any weight-bearing. After open reduction of congenital dislocations of the hip in relatively old patients, the rigid application of these principles helps to avoid osteo-arthritis. In both atrophic and hypertrophic types of chronic osteo-arthritis, these measures are very useful adjuncts to other lines of treatment.

The problem of restoration of movement after tuberculous infection of the weight-bearing joints was treated by the lecturer with considerable reserve, but he felt that if means of rapidly controlling the disease were perfected, as for instance by the Robertson-Lavalle operation, there was a reasonable prospect of securing a safe range of movement by adopting the lines of treatment indicated.

ORTHOPAEDIC AND TRAUMATIC SURGERY IN RUSSIA

In response to the Editor's request, Prof. Tregubow, of Kharkov, has given the following brief statement in regard to orthopaedic and traumatic surgery in Russia.—*Editor.*

In Russia the chief center of orthopaedic surgery is Leningrad, where it is so well represented by Prof. Turner and Prof. Wreden, who have been actively instrumental in the development of this specialty in that part of Russia.

In the south, in the Ukraine, orthopaedic surgery received a great stimulus by the work of Dr. T. Finck, who for so many years represented this department of surgery at Kharkov, and the work first developed by him has been continued by his pupils, who are maintaining the standards established by him.

Until very recently orthopaedic surgery has not been represented in the medical schools as an independent and required course, but in this regard the War played an important part in this country, as in others. In the Ukraine, following the War, orthopaedic surgery was made a compulsory course and, in 1921, Chairs for this subject were established in the Universities of Kharkov, Kiev, Odessa, and Dneipropetropsk. At Kharkov and Kiev there were also organized special clinics for orthopaedic and traumatic surgery, with special workshops for the providing of prostheses. In addition, in the Crimea, in the Caucasus, as well as in several other centers, there have been erected sanatoria for the care and treatment of cases of bone tuberculosis.

Until 1929 orthopaedic surgery was treated as an optional, second-class subject. This fact is illustrated by the number of hours which have been allotted to the teaching of orthopaedic surgery at Kharkov: in 1921, ninety-six hours; in 1923, seventy-two hours; in 1925, sixty-four hours; in 1927, fifty-six hours; in 1928, forty-six hours; in 1929, seventy-five hours. This list is interesting, since it shows a tendency from 1921 to 1928 to diminish rather than increase the amount of time allotted to this subject. It was of course quite impossible to instruct the students adequately in the forty-six hours allotted in 1928, and in 1929 the name of the department for the teaching of orthopaedic surgery was changed to the Department of Orthopaedic and Traumatic Surgery, and the number of hours allotted for teaching increased to seventy-five. This change indicates the beginning of a more cooperative relation and a better recognition of the place occupied by these two subjects in relation to the other divisions of surgery. It can be stated now that in the schools of the Ukraine the position of orthopaedic surgery compares favorably with its position in Western Europe, and it even approaches the situation in some of the

American universities. In other parts of the Soviet Union this subject is not obligatory, and in some medical schools is regarded only as an elective study for those students who intend to fit themselves as docents. So, as yet, there is no harmony of opinion as to the importance of this subject.

In the Department of Orthopaedic Surgery in the University of Kharkov, the seventy-five hours allotted to orthopaedic and traumatic surgery are distributed as follows: twelve two-hour lectures are given on fundamental subjects of the specialty, and the remaining fifty-one hours are used,—first, for practical demonstration and instruction on the most important branches,—such as inherited deformities, fractures, infantile paralysis, and bone tuberculosis; second, in ambulance work, which gives to the students a large opportunity for intimate acquaintance with practical clinical work; third, in the technique of orthopaedic surgery, including plaster work, instruction in the preparation of apparatus and prostheses; fourth, experience in visiting patients, attending operations, and handling dressings; fifth, the principles of massage and medical gymnastics. This practical experience is followed by more class-room work.

The relation of the orthopaedic institutions to the People's Commissariat of Health renders possible the close affiliation between all existing institutions and their successful cooperation for teaching. For this reason there is an increasing desire on the part of all professors of orthopaedic surgery in the medical colleges that in the future organization there shall be harmonious relation between all orthopaedic institutions. Through the *Dispenseur* there must be the necessary connection between the stationary hospital and the workshop for prostheses; the work for crippled children must have consideration in general and professional education; the treatment of bone tuberculosis requires sanatoria equipped with heliotherapy and workshops for the manufacture of orthopaedic apparatus.

There is, as yet, no Orthopaedic Congress in Russia, but since 1925 there has been added to the Surgical Congress a day, devoted to the consideration of orthopaedic reports, etc., called an Orthopaedic Day. Following the last Congress a conference was held for the consideration of subjects dealing with orthopaedic surgery and trauma of the locomotive apparatus. A similar conference will be held at the next Surgical Congress, and it is hoped that this may be the beginning of a special congress for orthopaedic surgery.

Already in Leningrad, Kharkov, and Kiev there have been organized orthopaedic associations, and since 1927 a special journal of orthopaedic and traumatic surgery has been published at Kharkov (*Orthopaedia i Travmatologia*). It is expected that soon a law will be passed for the obligatory registration of all hereditary and acquired deformities; also a regular and systematic effort for reporting the facts and preserving the statistics in all orthopaedic cases. Thus a basis for an orthopaedic organization has already been established and emphasis is being placed on the importance of orthopaedic surgery in medical education.—*S. Tregubow, Kharkov, U. S. S. R.*

At the meeting of the **Reunion d'Orthopédie et de Chirurgie de l'Appareil Moteur de Bordeaux,** held on March 26, 1931, a report was presented by Dr. Charles Lasserre on Two Cases of Vertebral Lymphogranulomatosa.

In the course of malignant lymphogranulomatosa, which is now considered as an inflammatory disease, progressively invading the whole lymphatic system, and manifesting itself in the same individual in different localities, often remote from each other, the bony framework—especially the vertebral column—often presents lesions that are particularly characteristic. Dr. Lasserre reported two observations of this disease of the vertebral column. The first case was in a young woman of twenty-seven years, affected since June 1929 with multiple ganglion lesions of which the anatomical and pathological examination by biopsy demonstrated the diagnosis. Since December 1929 she had had severe pain in the lumbar region, and on January 20, 1931, the x-ray demonstrated the following lesions: the shape of the first lumbar vertebra is altered; the opacity of the vertebral body on the left of the median line is definitely increased; stalactite proliferation in the neighborhood of the disc of the first and second lumbar vertebrae is observed; the right portion of the vertebral body has partly disappeared; the lateral border is indistinguishable; the zones of condensation and rarification are contiguous; the calcified zones appear

FIG. 1

to emanate from the vertebrae and to extend below and to the right as far as the second lumbar vertebra; the discs above and below are intact; in the paravertebral region on the right the mass has a clearly rounded contour (See Figure 1.). Roentgen therapy resulted in the rapid disappearance of the pain about the waist, which had been severe.

The second observation was an x-ray report which showed a case of lymphogranulomatosa with typical flattening to nearly a complete disappearance of the body of the second lumbar, with the intervertebral discs intact. Dr. Lasserre gave a résumé of the present knowledge of this interesting question. He drew attention to the bony lesions which are encountered in such a case. The areolar form and the metastatic type of vertebral lymphogranulomatosa appear to develop from an invasion of the spongy tissue and he observed that in the erosive forms there is evidently an invasion from place to place of the gangliomatous mass. The lesions in these cases have not been characteristically osteoporotic but have shown an apparent condensation in the zones of destruction, which are more or less extensive.

A paper on Paget's disease was presented by Dr. Gourdon and Dr. Payre. They reported the case of a man, fifty-five years old, who, in 1917, had severe infection, following which there were noticed symptoms of arteriosclerosis and nephritis. Soon afterwards there appeared pain in back, and a general kyphosis, involving the whole spine. This increased slowly and was accompanied by deformities of the pelvis, both lower and upper limbs, and the skull.

At present—fourteen years afterwards—the entire skeleton is involved, with characteristic findings of Paget's disease: increase of the anteroposterior diameter of the skull, deformity of the diaphyses of the long bones, genu varum, etc. The x-rays of the pelvis and of the skull are particularly interesting, showing the bony striata resembling a fraying out of cloth. The outline of the bones of the ilium has disappeared and, on the contrary, the contours of the pubis are thickened. The skull is distinctly elongated in its anteroposterior diameter; the internal table is opaque and the external has a cotton-like appearance.

The diagnosis of Paget's disease is definite from the clinical symptoms and the roentgenograms, but it is difficult to explain the origin of this case. The early vascular disturbance and the change in posture and general appearance with failure of the assimilation of the constituent substances of bone are evident, but these conditions do not furnish a sufficient explanation of the association of this process of osseous rarefication and condensation, or of the inverse number of osteoblasts in relation to the osteoclasts.

Current Literature

FRACTURES OF THE JAWS. By Robert H. Ivy, M.D., D.D.S., F.A.C.S., and Lawrence Curtis, A.B., M.D., D.D.S. Philadelphia, Lea & Febiger, 1931. $4.50.

The purpose of the authors has been to simplify the treatment of this important subject, so that proper, early treatment may be given by surgeon, dentist, or oral surgical specialist. The anatomy of the jaws is reviewed with a large number of excellent illustrations. The authors then proceed in a very orderly manner to discuss the general principles of fracture treatment, then, in detail, the treatment of simple fractures of the mandible, with a chapter devoted to the complications of fractures of this bone. Other chapters deal with fractures of the maxilla, malar bone, and zygomatic arch, roentgenographic technique, and the dietary management of fractures of the jaw.

The text is well written and the illustrations are excellent. The details of the more important methods are made very clear. The arrangement is good, lending itself to quick reference. The book is a decided addition to the literature of fractures as a whole and to fractures of the jaw in particular.

PRACTICAL X-RAY TREATMENT. By Arthur W. Erskine, M.D. St. Paul, Minn., Bruce Publishing Co., 1931. $3.50.

A practical book of 116 pages, with charts, tables, and illustrations, setting forth the author's opinions on roentgenotherapy, in a very readable manner. Three standard techniques, using 135 kilovolts, and one of 200 kilovolts are used to cover skin, nonmalignant, and malignant conditions. The value of x-ray treatments in the various lesions is honestly set forth. The danger of underdosage as well as overdosage is pointed out.

This book is especially useful to those seeking information on modern roentgen therapy and the author's opinions expressed in his chapter on malignant conditions show him to be a careful and conservative thinker.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

*Diagnosis in Joint Disease. By Nathaniel Allison, M.D., F.A.C.S., and Ralph K. Ghormley, M.D. New York, William Wood & Company, 1931. $9.00.

*Clinical Observations on the Surgical Pathology of Bone. By David M. Grieg. Edinburgh, Oliver & Boyd Ltd., 1931. 30 shillings.

Les Déplacements divers du Nucleus Pulposus intervertébral (Ante, Latéro et Rétropulsions) (Luxation postérieure et Paraplégie). By Marcel Galland. Archives Franco-Belges de Chirurgie, XXXII, No. 6, 1930.

Rapport sur le Traitement de la Coxalgie. By Marcel Galland. VI Congrès de l'Association Internationale de Thalassothérapie, Berck, 1931.

Störungen des Knochenwachstums bei tuberkulösen Erkrankungen des Skeletts. By Prof. S. Tregubow. Zeitschrift für orthopädische Chirurgie, LIII, 482, 1931.

Die Rolle der Orthopädie als Lehrfach im medizinischen Unterricht. By Prof. S. Tregubow. Zeitschrift für orthopädische Chirurgie, LV, 8, 1931.

Twenty-Fourth Annual Report of The Hospital for Joint Diseases of the City of New York for the Year 1930. New York, 1931.

Zum Arbeitsgebiet der Orthopädie; Die Mechanopathologie des Beines. By Dr. Erwin Schrader. Medizinische Klinik, No. 34, 1930.

Sur Diagnostik der Kahnbeinbrüche der Hand. By Dr. Erwin Schrader. Monatsschrift für Unfallheilkunde, XXXVIII, 266, 1931.

*To be reviewed in a later issue of *The Journal*.

Theoretisches zur unblutigen Behandlung in der Orthopädie. By Dr. Erwin Schrader. Die Medizinische Welt, No. 2, 1931.

Die Meniscusschäden; Eine häufig verkannte Binnenverletzung des Kniegelenks. By Dr. Erwin Schrader. Die Medizinische Welt, No. 16, 1931.

Die Grundsätze der mechanischen Behandlung in der Orthopädie. By Dr. Erwin Schrader. Beilageheft der Zeitschrift für orthopädische Chirurgie, LIII, 242, 1931.

Bulletin of the National Tuberculosis Association. New York, Vol. XVII, Nos. 7, 8, 9, July, August and September 1931.

Annaes Paulistas de Medicina e Cirurgia. S. Paulo, Brazil, Vol. XXII, No. 8, August 1931.

Absetzung und Auslösung an den unteren Gliedmassen und ihr Kunstersatz. By Prof. M. zur Verth. Zentralblatt für Chirurgie, No. 25, 1581, 1931.

Wo is die Rachitis hingekommen? By Dr. A. Schanz. Die Medizinische Welt, No. 30, 1931.

The Johns Hopkins University Circular, School of Hygiene and Public Health, Catalogue 1931-32. Baltimore, No. 5, May 1931.

Aus der Geschichte der Orthopädie. By Prof. G. Hohmann. Die Medizinische Welt, No. 5, 1931.

Ortopedia e Traumatologie dell' Apparato Motore. Rome, Vol. III, Fasc. 2 and 3, April and June 1931.

United Fruit Company, Medical Department, Nineteenth Annual Report, 1930. Boston, 1931.

Journal de Médecine de Bordeaux et du Sud-Ouest. Bordeaux, Vol. CVIII, No. 13, May 10, 1931.

Über indirekte isolierte Frakturen an den Proc. spinosi der unteren Hals- und oberen Brust-wirbelsäule (Indirect Isolated Fractures of the Spinous Processes of the Lower Cervical and Upper Dorsal Vertebrae). C. Sandahl. *Acta Chir. Scandinavica*, LXVIII, 171, 1931.

Two cases are reported in which sudden muscular force resulted in the fracture of a spinous process. The antagonistic action of the serratus magnus against the rhomboids and horizontal fibers of the trapezius was probably responsible.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Durch Überbelastung hervorgerufene Knochenerkrankungen (The Bone Lesions of Over-strain). E. J. Närvi. *Acta Chir. Scandinavica*, LXVIII, 211, 1931.

The so called "march fracture" presents a typical picture of painful swelling of the dorsum of the foot following unusual, excessive walking or long marching. X-rays show periostitis with atrophy of the distal end of the metatarsal, usually the second or third. Frequently one sees a distinct fissure with surrounding callus. The process heals in six to eight weeks.

The writer agrees with Ollonqvist that a similar condition appears in the tibia and fibula following unusual exertion. X-rays and cases are presented in support of the theory that excessive use produces stasis and thrombosis of the vessels of the soft parts surrounding the bone. Disturbance of the nutrition of the periosteum leads to tender swelling of it and in turn to disturbed nutrition of the bone. Resorption of the cortex gives the appearance of fissures. Callus formation and ossification follow. Bacteriologic studies were negative. The writer denies an infectious cause and the likelihood of a mechanical infraction.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Zwei Fälle von Achondroplasie (Two Cases of Achondroplasia). N. Mesz, J. Fliederbaum, R. Markuszewiez. *Acta Radiologica*, XII, 59, 1931.

Two males with achondroplasia are presented, one aged forty-seven, and one aged sixteen. The first presented evidence of familial achondroplasia. They distinguish, in the fashion of Tschougounoff and Sourkoff, a peripheral and a central type, and call their first case central, their second, peripheral.

They are inclined to blame the hypophysis for the syndrome and find support for this contention in an absence of the sella turcica in one case, and a diminution and malformation of it in the other. The literature on the pathogenesis is not enlightening.

An interesting tabulation of the two cases is included:

A. Common external characteristics:

1. Short stature (126 to 109 centimeters),
2. Almost normal trunk with marked extremity shortening,
3. Depressed bridge of nose,
4. Marked lumbar lordosis,
5. Hydrocephalic skull with ball-shaped forehead,
6. High gluteal fat pad,
7. Upper extremities reach to level of hip joint,
8. Short, broad hands and feet,
9. Curving of the forearms.

B. Common roentgenological characteristics:

1. Large skull with increased cranium and thick skull bones,
2. Absence or fattening of the clivus,
3. Small or hardly indicated sella turcica,
4. Large nasal sinuses,
5. Small, narrow, flat pelvis with large obturator foramina,
6. Large olecranons interfering with full extension,
7. Small and flat acetabulum,
8. Curving of forearm bones with shortening of the distal end of the ulna,
9. Fibula longer than the tibia,
10. Increased cortex and broadening of the upper extremity bones with prominence of muscle insertions,
11. Flattened vertebral bodies.

C. External differing characteristics:

Case 1.	Case 2.
1. Genu varum,	1. Genu valgum,
2. Heavy musculature,	2. Weak musculature,
3. Small penis,	3. Large penis,
4. Normal hair growth,	4. Sparse hair growth,
5. Central character of the extremity shortening.	5. Peripheral character of the extremity shortening.

D. Roentgenological differing characteristics:

1. The epiphyseal ends and the metaphyses are much broader in Case 1 than in Case 2.
2. The cortex is much thickened in Case 1.
3. The muscle insertions are more prominent in Case 1.
4. In Case 2 the vertebral bodies are more flat and the intervertebral spaces broader.
5. The base of the skull is shorter and more flat in Case 1.—*J. E. Milgram, M.D., Iowa City, Iowa.*

Das Kreuzbein und die Lumbosakralgegend (The Sacrum and the Lumbosacral Region). Paul Lübke. *Arch. f. klin. Chir.*, CLXIII, 707, 1931.

From the study of 200 autopsy specimens of the sacrum and the lumbosacral junction, the author found that in thirty-one per cent. the sacrum consisted of six well formed segments. The lumbosacral transition form of the twenty-fifth vertebra (lumbarization) was found in nine per cent., that of the twenty-fourth vertebra (sacralization) in one per cent.; a nearthrosis between the transverse process and the sacrum was present in ten per cent. A possible cause of pain, according to anatomical findings,

is seen only in the nearthrosis and in the lumbosacral transitional vertebra in which the bony union with the sacrum was absent. Spina bifida was found in twenty-four per cent. Arthritic changes in the lumbosacral region were absent in sixty-four per cent. of patients from twenty to thirty years of age; in thirty-eight per cent. up to forty years; and in only three per cent. over forty years of age.

Spondylolisthesis was found in three cases. These showed a cleft in the interarticular portions.

A study of the most severe forms of scoliosis in the large collection of material at Schmorl's Institute, showed that in no case, could the curvature be traced to sacralization or to lumbarization.—*R. J. Dittrich, M.D., Wichita, Kansas.*

ERGEBNISSE DER UNTERSUCHUNG AUF RUHENDE INFEKTION AN EXTREMITÄTEN (Results of Examination for Latent Infection of Extremities). B. Maske. *Arch. f. klin. Chir.*, CLXIV, 58, 1931.

The author uses the method of Payr to determine the presence of a latent infection in the joints. This consists of: (1) an accurate examination of the blood and (2) determination of the skin temperature over the suspected location.

The blood examination includes: determination of hemoglobin, erythrocyte count, leucocyte count (general and local), and sedimentation test. After obtaining a temperature reading of the skin over the suspected area and likewise over the corresponding area of the sound extremity, both joints are subjected to a vigorous massage for a period of ten minutes. Following this the skin temperature is determined every twenty minutes for one hour. A further test is the estimation of the skin temperature following roentgen irradiation of the joint. The presence of a latent infection is determined by the blood picture and the skin reactions as shown by the temperature variations following massage and irradiation.

To show the efficacy of these diagnostic methods the author states that of twenty patients with a positive diagnosis of infection, subjected to operation, only six were successful, the rest developing complications. On the other hand, of seven patients with negative results only two developed infection.—*R. J. Dittrich, M.D., Wichita, Kansas.*

BEHANDLUNG UND ENDAUSGÄNGE DER UNSPEZIFISCHEN EITERIGEN ENTSÜNDUNGEN DER GROSSEN GELENKE (Treatment and End-results of Non-specific, Suppurative Inflammations of the Large Joints). A. Kortzeborn und F. Hesse. *Arch. f. klin. Chir.*, CLXIV, 95, 1931.

In the treatment of acute suppurations of joints conservative treatment has proved to be very valuable (sterilization of joint cavity by puncture and injection of phenol-camphor, retention of the closed joint cavity, application of heat, and early active motion). Of twenty-seven cases of Group A (bacteriologically sterile), function was completely restored in twenty-one, partly restored in two, and unsatisfactory in four cases. Group B consists of cases in which staphylococci or streptococci were the causative factor and in which the same treatment was used. Of nineteen cases of this group, four had complete function, four had partial function, four had ankylosed joints, six died, and one had a flail joint.

Group C comprises the cases in which it was impossible to avoid a wide incision into the joint. Of thirty-five patients in this group, one had complete function, eight had partial function (one case involved two joints), twenty had an ankylosed joint and seven died.

The authors much prefer the conservative treatment, but when operative drainage is necessary, they emphasize the necessity of wide incisions, as there is, at best, very little hope of recovering the use of the joint.

The article shows, in tabulated form, data referring to location of the disease, bacteriological studies, and individual cases.—*R. J. Dittrich, M.D., Wichita, Kansas.*

UNTERSUCHUNGEN ÜBER DIE LOKALISATION VON ABSCESSEN IN JUGENDLICHEN KNOCHEN NACH DIREKTER INFEKTION DER MARKHÖHLE (Investigations on Localization of Abscesses in Young Bones After Direct Infection of the Bone Marrow). Walther Müller. *Arch. f. klin. Chir.*, CLXIV, 722, 1931.

Experiments on rabbits consisted of injecting various materials (dyes, suspensions of talcum, bacterial suspensions) into the marrow cavity of long bones. It was observed that in the experimental application of bacteria into the marrow cavity of the bones, as well as by injecting sterile solutions or suspensions of other materials, a definite collection of these materials took place at the metaphyseal ends of the bones; and that, as a result of this, infectious processes are more commonly located in these areas. For the origin of osteomyelitic processes in the metaphyseal regions of growing bones, this principle must be kept in mind, in addition to the principle of purely embolic origin.—*R. J. Dittrich, M.D., Wichita, Kansas.*

ÜBER DIE VITASTERINSCHÄDIGUNG DER FRAKTURHEILUNG (Injury by Vitasterin in Healing of Fractures). A. Tammann. *Arch. f. klin. Chir.*, CLXV, 473, 1931.

The author performed experiments on rabbits to determine the amount of damage caused by excessive amounts of vitasterin, a vitamin-D product. These consisted of a study of the healing of fractures. In some of the animals the injury consisted of a delayed callus formation. In all animals, in whom it was possible to administer sufficient amounts of vitasterin, a marked injury of the callus was noted, which in mild form was seen as an atrophy. In severe form the atrophic callus showed fractures. Chemical analysis showed that bone injured by vitasterin had less water than normal bone and that with increasing amounts of vitasterin, there was an increasing loss of minerals. Histologically there were necroses of the media and calcification of the arterioles.—*R. J. Dittrich, M.D., Wichita, Kansas.*

CYSTEN IM KREUZBEIN (Cysts of the Sacrum). G. Kleiner. *Beitr. z. Path. Anat. u. z. allgem. Pathol.*, LXXXVI, 407, 1931.

The author examined 4300 spines at autopsy and discovered cysts of the sacrum in forty-eight (1.1 per cent.). These cysts were most frequent at the level of the second sacral segment, were covered with dura mater, and filled with fluid. The spinal canal at the level of the cyst is enlarged anteriorly. A connection between the cyst and the dural sac existed in six cases. The cysts vary in size and frequently nerves are found in the walls. Microscopically, calcification and ossification are found in the cyst wall, but no inflammatory process.

In this congenital malformation, which is designated as spina bifida incompleta anterior (or posterior) there exists, as in spina bifida occulta, the remains of a partly healed embryonic spina bifida cystica. We may assume that following intra-uterine bursting and collapse of the cyst, the bony cleft was completely overgrown and only an intrasacral slowly growing meningocele remained, which later enlarged the canal by pressure atrophy. However, the enlargement of the canal may also be interpreted as an incomplete healing of the primary spinal cleft. The sacral cysts in these cases were not noted during life.—*R. J. Dittrich, M.D., Wichita, Kansas.*

THE OPERATIVE TREATMENT OF POTT'S PARAPLEGIA. G. R. Girdlestone. *British J. Surg.*, XIX, 121, July 1931.

Early decompression, either laminectomy or costotransversectomy or both, together with bone grafting, is advocated for Pott's diseases with paraplegia. The author advises operative fixation for spinal caries in adults, even if there is no paralysis. If bone grafting is done, the door is closed for future laminectomy; hence his belief that they should be done at the same time.

Twelve cases are reported with two deaths, partial recovery in four, complete recovery in five, and one case too recent to state results.

On combining the laminectomy and graft, care is taken to reflect osteoperiosteal flaps from the spinous processes, pushing them laterally with the muscles. Twin grafts of considerable size are prepared, to be placed on either side of the spinous processes or to replace the process at the site of the laminectomy. Emphasis is laid on continuous immobilization of the whole spine, before, during, and after operation.

Traumatic Arrest of Epiphyseal Growth at the Lower End of the Tibia. Bryan McFarland. *British J. Surg.*, XIX, 78, July 1931.

The lower tibial epiphysis is rarely displaced bodily. Usually injury is caused by an inward twist of the foot with forcible adduction of the astragalus, and with a crushing force exerted on the inner half of the epiphyseal plate of the tibia. The epiphysis breaks at the base of the malleolus.

A typical case is described of a boy who had received an injury a year previously with very little disability. Just previous to this entry he had sustained a slight injury. X-rays showed an old fracture of the epiphysis which had given no trouble until a deformity appeared. The epiphysis in these cases becomes united to the diaphysis at the point of injury with cessation of growth. The outer half, together with the fibula, continues to grow, with a resulting turning in of the ankle joint.

Treatment should be postponed until fourteen years of age,—better until eighteen or twenty. Through an external incision the fibula is exposed above the ankle joint. A wedge, consisting of fibula and three-fourths the thickness of the tibia, is removed. The line of this passes through the interosseous ligament where the two bones are practically in contact. The upper surface of the wedge should be horizontal, the lower parallel with the lower tibial articular surface.

Observations on Some Tendon Ruptures. Harry Platt. *British Med. J.*, I, 611, Apr. 11, 1931.

Platt contributes a useful and interesting article on a little known subject. In it he gathers together in a concise manner, all the essential knowledge concerning the most commonly seen tendon ruptures. He prefaces his remarks by the statement that tendon ruptures may be divided into two main groups: (1) rupture produced by sudden powerful overstretching of a muscle already in a state of contraction, and (2) an insidious form of spontaneous rupture due to attrition of the tendon where it runs through a bony groove. He then discusses in detail: (1) ruptures of the extensor tendons of the fingers (mallet fingers); (2) rupture of the long head of the biceps; (3) rupture of the distal tendon of insertion of the biceps; (4) rupture of the extensor pollicis longus; (5) rupture of the flexor tendons; (6) rupture of the tendo achillis; (7) ruptures of the extensor apparatus of the knee. The article is well written and informative and is illustrated. The various types of tendon ruptures are exemplified by cases from his own practice.—*R. I. Harris, M.B., Toronto, Canada.*

Lines of Arrested Growth in the Long Bones of Diabetic Children. H. A. Harris. *British Med. J.*, I, 700, Apr. 25, 1931.

Harris records the observation that the growth of long bones of diabetic children is intermittently arrested at times which correspond to exacerbation of the disease or to intercurrent infections. The lines of increased density thus formed are more marked in the lower than in the upper limb. Two excellent reproductions of radiograms accompany the article.—*R. I. Harris, M.B., Toronto, Canada.*

Remarks on Treatment of Recent Simple Fractures of Long Bones. C. H. Fagge. *British Med. J.*, I, 735, May 2, 1931.

Fagge outlines the principles necessary in the treatment of fractures. He lays down as the first requirement the restoration of anatomical relationship of the fragments. This he attempts to attain by manipulation under anaesthesia with retention

in plaster. If the x-ray shows an unsatisfactory result, skeletal traction is tried in appropriate cases. If this fails, open operation is resorted to. He defends the more wide-spread use of open reduction. All fractures involving joints, he feels, are best treated by open operation. He disputes the necessity of acute flexion of the elbow in the treatment of supracondylar fractures. If the fragments are accurately replaced, right-angled flexion is sufficient and diminishes the danger of Volkmann's contracture. In after-treatment he lays most stress on active movements without resistance or weight-bearing.—*R. I. Harris, M.B., Toronto, Canada.*

OBSERVATIONS ON FRACTURES OF THE NECK OF THE FEMUR. Sir Robert Jones. *British Med. J.*, I, 781, May 9, 1931.

Sir Robert discusses first the slipping epiphysis of adolescence. Treatment consists of fixation without abduction in those cases of epiphyseal strain in which there is not yet any displacement of the epiphysis, and fixation in abduction where the epiphysis has slipped.

Fractures of the femoral neck in the aged, he divides, as is usual, into intracapsular and extracapsular. The main cause of non-union in the intracapsular type is due to imperfect apposition, but in part also to imperfect power of osteogenesis and imperfect blood supply. Treatment consists of disimpaction of the fragments and their reduction and fixation by the Whitman method. Results are discussed with quotations from published statistics. He feels that in seventy-five per cent. of intracapsular fractures, union can be expected. He is against open operation in the recent case on the grounds that it should not often be necessary and that it increases the risk.

Treatment of old ununited fractures is discussed under the heads of pegging operations, Whitman's reconstruction operation, Brackett's operation, bifurcation operation, and removal of the head of the femur. In the aged, he strongly favors the bifurcation operation and in the young, some type of bone-pegging operation.—*R. I. Harris, M.B., Toronto, Canada.*

STATURE AND POSE. THE PROBLEM OF UNEQUAL LEGS. Ernest W. Hey Groves. *British Med. J.*, II, 1, July 4, 1931.

Under this title Hey Groves discusses the disabilities and deformities of the lower extremity due to shortening of one leg, to various disturbances of the hip joint and to ankylosis of the hip in bad position. Shortening of a lower extremity may be due to malunion of a fracture of femur or tibia, to the atrophy of poliomyelitis, or to such conditions as congenital dislocation of the hip. Ankylosis of the hip in adduction results in relative shortening, because of the pelvic tilt necessary to keep the limbs parallel.

Under treatment he first discusses the prevention of shortening due to fractures. He strongly favors skeletal traction and speaks with especial favor for transfixion pins embedded in plaster. He discusses briefly the problem of lengthening the unbroken bone by osteotomies and prolonged skeletal traction. He does not favor this measure so much as shortening of the sound limb. For shortening due to angulation or bowing, he advocates multiple osteotomies and skeletal traction. For shortening due to fixed adduction of the hip he uses Lorenz' bifurcation operation. As far as one can judge from his paper, this does not achieve more than a simple subtrochanteric osteotomy. The article is well illustrated by diagrams.—*R. I. Harris, M.B., Toronto, Canada.*

HEREDITY AND DUPUYTREN'S CONTRACTION. J. S. Manson. *British Med. J.*, II, 11, July 4, 1931.

Manson reports four cases of Dupuytren's contracture occurring in two generations of a family. All the sons of the affected father have the deformity in both hands. The daughters are unaffected. The third generation is as yet too young to have developed the disease.—*R. I. Harris, M.B., Toronto, Canada.*

DIE SEQUESTERBILDUNG BEI DER KNOCHENTUBERKULOSE (Sequestrum Formation in Bone Tuberculosis). Hans Hellner. *Bruns' Beitr. z. klin. Chir.*, CLI, 36, 1930.

The tubercle bacillus may call forth every form of histological inflammation process in the marrow cavity. There are proliferative, exudative, and necrotizing forms with mixtures of all three. Bone tuberculosis is a blood-borne embolic lesion.

Various forms are seen:

1. Caries sicca, a slow resorption through tuberculous granulation tissue, with no sequestration.
2. Fungous bone tuberculosis. Small holes appear filled with the specific granulation tissue. Pus appears. Innumerable tiny sequestra are present. This is also a slow process.
3. A rapid, extensive caseation of the granulation tissue without dissolution of the tissue leads to the formation of large sequestra. Interference with circulation may be a feature.
4. With dissolution of the caseous granulation tissue, a bone cavity or bone abscess may form. In it may lie a large sequestrum.
5. Furthermore, closure of a vessel may be followed by the formation of a sequestrum. A caseous infarct (*Fedor Krause*) may form, and in most cases is sequestrated.

Sequestra are not very common. Of 346 cases of bone tuberculosis at the University Clinic at Münster, only six cases revealed clearly demarcated sequestra. The acetabular roof and the head of the femur are especially prone to be so afflicted.

Conservative treatment is recommended.—*J. E. Milgram, M.D., Iowa City, Iowa.*

SPONDYLOLISTHESE, PSEUDOSPONDYLOLISTHESE UND WIRBELVERSCHIEBUNG NACH HINTEN (Spondylolisthesis, Pseudospondylolisthesis and Backward Displacement of Vertebra). H. Junghanns. *Bruns' Beitr z. klin. Chir.*, CLI, 376, 1931.

From the study of autopsy material at Schmorl's Institute, the author distinguishes three types of slipping of the vertebrae.

1. True spondylolisthesis was found in sixteen men and nineteen women. (Twenty-three in the fifth lumbar, eleven in the fourth, and one in the third.) All these cases showed a cleft of the interarticular portion of the involved vertebra. This is probably a congenital, abnormally developed, non-ossified epiphysis. As a result of this cleft, the vertebral body, together with the root of the arch and the upper articular process, can slide forward after trauma has caused a relaxation of the ligaments. The posterior portion of the arch (inferior articular process and spinous process) retains its normal position and joint connection.

2. Pseudospondylolisthesis was observed twice in men and nine times in women (two in fifth lumbar, seven in fourth lumbar, and two in third lumbar). In this the inferior articular processes of the slipping vertebra are situated more horizontally and the joint spaces of the joints between the slipping vertebra and the one underneath are directed less vertically than the upper ones. By these relations the occurrence of a luxation is favored.

3. Backward displacement of vertebrae is rare (six in second lumbar and one in first lumbar) and always mild. The cause seems to be a primary injury and narrowing (by trauma or degenerative process) of the intervertebral disc. As the vertebral body above the narrowed intervertebral disc approaches the one below it, it is forced backward in conformity with the direction of the interarticular joint space.—*R. J. Dittrich, M.D., Wichita, Kansas.*

KIENBÖCK'S DISEASE. N. Austin Cary and Leonard Barnard. *California and Western Med.*, XXXIV, 36, Jan. 1931.

After reviewing the literature and history of this disease, the authors find that only about seventy cases have been reported. They believe that many cases go unrecognized. The etiology of their cases was traumatic, the patient falling on his hand with

the wrist in dorsiflexion. The symptoms are pain in the wrist, lasting from several hours to several days, accompanied by moderate swelling which rapidly disappears. After one to nine months later symptoms appear, however, and pain on jarring and hyperextension and swelling over the dorsum of the wrist are increased with usage. There is localized tenderness over the involved carpal bone. Dorsiflexion is decreased. The x-ray shows the lunate bone compressed to from two-thirds to one-third its normal size. Later there is absorption or decalcification which gives the appearance of multiple fractures.

As to treatment, Mueller curretted the soft, cancellous bone and obtained good results. Henderson advocates conservative treatment. Goldsmith advises immobilization with dorsivolar pressure and extension on the middle finger. The authors conclude that in the late cases removal of the involved bone is indicated. They use the volar approach and apply no splinting afterwards. Two cases are reported, each having received physiotherapy including rest, radiant heat, massage and, in one case, diathermy. Improvement followed, but the patients were unable to work. Both then consented to operation; ultimate results showed freedom from pain on working, although flexion and extension of the wrists were limited to about four-fifths normal.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

Difficult Fractures. W. C. Adams. *California and Western Med.*, XXXIV, 77, Feb. 1931.

The author calls attention to the greatly improved hospital facilities now rendering safe bone operative work which formerly was considered precarious. He therefore advises open reduction in many cases which would otherwise require prolonged immobilization with subsequent stiffness of joints and muscle atrophy. He reports seven severe cases of fracture, all but two of which were treated by the open method, with the application of either Lane plates or Dukes bone plates. In cases of infection of both bone and soft tissues he obtained excellent results by keeping the region immersed in a one-to-five thousand mercury bichlorid solution saturated with magnesium sulphate.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

Susceptibility to Tumors—Some of the Factors Governing the Same. Charles L. Conner. *California and Western Med.*, XXXIV, 325, May 1931.

The author divides experimental tumors into transplantable and inoculable: the first is the transmission of living cells; the second, the use of extracts or dried tumor tissue. By successive inoculations the tumor Rous fibrosarcoma may adapt itself to various strains of chickens; also strains of moderately susceptible animals may be bred into strains susceptible to tumor growth, and *vice versa*. This indicates an inheritable character of tumor adaptation. Artificial tumors, or masses of growing tissue, may be transmitted to another location in the same animal; less readily to another of the same species, and not at all to a different species. A tissue which has great power of regeneration—*e.g.*, the thyroid—takes best in a transplant. Chick embryos transplanted develop as teratomata, but continued transplantations develop embryonal fibrosarcomata. The specie specificity persists here. Endotheliomata take best in the young chicks, while carcinoma takes best in mice of an older age. There is definite evidence that various kinds of tumors are inherited and follow racial strains.

The author divides malignant tumors into: first, "virulent"; and second, those that continue to grow after being transplanted. Examples of the first are carcinoma and sarcoma; of the second, embryonal fibrosarcoma of children, adamantinomata, chordomata, and "mixed" tumors of the parotid. A very few examples of voluntary human transplants have been made. The papillary cystomata of the ovary may rupture and become malignant. Transmissible tumors in animals often undergo retrogression with the ripening of the sex glands. The same has been reported to occur in the human. There must, therefore, be some special factor present in such persons and in totally

immune individuals. Hence one hope of systemic treatment of cancer lies in supplying actively or passively this unknown hereditary or racial factor.

Aside from actual destructive agents, a legion of other artificial methods of treatment have been tried. The following reactions are reported by various authorities:

1. Tumor growth is made more active by,
   (*a*) Removal of the spleen.
   (*b*) Thyroid extract (in some animals).
   (*c*) Parathyroid hormone (in tumors of rats).
   (*d*) Insulin (in sarcoma in rats).
   (*e*) Adrenalin.
   (*f*) Protein or colloidal solution (in some tumors).
2. Tumor growth is not affected by,
   (*a*) Thymus extract (this acts as a foreign protein).
   (*b*) Adrenal cortical extracts (in fibrosarcoma in chickens).
3. Tumor growth is inhibited by,
   (*a*) Potassium-deficient diet.
   (*b*) Vitimin-B-deficient diet.
   (*c*) Decreased atmospheric pressure (in rat sarcoma).—*Charles Lyle Hawk, M.D., Los Angeles, California.*

FRACTURE DISLOCATIONS OF THE LOWER CERVICAL SPINE. H. W. Spiers. *California and Western Med.*, XXXIV, 348, May 1931.

The author, after discussing the symptoms of and the principles of reduction of fractures of the cervical spine, reports his method of procedure in seven cases. According to his method the patient is placed on the bed in which he is to remain and, under anaesthesia, while the patient is being held by assistants, the neck is manipulated and traction applied at the same time. The operator stands at the head of the bed and the traction is maintained by a head traction halter attached to a belt about his waist. He thus has both hands free to manipulate, which fundamentally consists of forward and lateral flexion of the head away from the locked facet. A lateral x-ray is then taken and the patient remains in five or six pounds' traction for three weeks, when a modified Thomas collar, which does not allow too much forward flexion of the head, is applied and he is allowed to sit up.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

CHANGES IN BONE TUMORS AFTER INTRAVENOUS INJECTIONS OF A COLLOID SOLUTION. A. C. Hendrick, and E. F. Burton. *Canadian Med. Assn. J.*, XXIV, 642, May 1931.

The metal is employed in colloidal solution as this form affords a very slow and prolonged action of the active element. The colloid must be negatively charged or it will precipitate the negative proteins of the blood.

The solution employed was a colloid solution of arsenic, negatively charged, and demonstrated to be safe for intravenous injection by animal experiment. Films were made at intervals of three months. Biopsy was not done.

CASE 1. Boy, aged eighteen, with periosteal sarcoma. Treated November 1928, with deep x-rays and Coley's fluid. In January 1929, fracture of the femur occurred; non-union. Injections of colloid until July; union good. Seen December 1930; condition satisfactory.

CASE 2. Female, aged forty-three, with paraplegia and brachial neuralgia. Growth, probably secondary, in the neck of the second rib, and in second thoracic vertebra. Colloidal injections and deep x-ray given from October 1929 until May 1930. Recalcification of the vertebra, and clinical improvement.

CASE 3. Male, aged twenty-three; diagnosis: "osteogenic sarcoma, left femur" (Bloodgood). Intravenous injections and deep x-ray from January to May; improvement.

CASE 4. Male, aged twenty-six. Osteosarcoma of the ilium, "with an extreme degree of development". Injections from May 1930 to March 1931. The degree of involvement remains very nearly the same.

In all the cases of the series increased calcification and ossification were noted in the radiograms.—*A. Gibson, M.D., Winnipeg, Canada.*

A CASE OF HAEMANGIO-ENDOTHELIOMA OF THE BONES OF THE WRIST. J. E. Pritchard. *Canadian Med. Assn. J.*, XXIV, 689, May 1931.

Male, aged 30, complained of soreness and swelling of the right wrist in December 1926. One month before he injured the wrist while cranking a car. Radiograph showed fracture of trapezium and of styloid process of radius. There was rarefaction of the lower end of radius, trapezium, scaphoid, and first metacarpal. Plaster was applied for nine weeks; no improvement. In October 1927, the destructive process was much increased, with swelling irregular, and pulsating, increased vascularity of the wrist and hand. Enlarged lymph glands in axilla. Deep x-ray given December 1927; no improvement; no metastases. Amputation was done through the lower third of the forearm.

Pathological Findings

Large reddish-brown fleshy mass, involving lower end of the radius, carpal, and metacarpal bones and soft parts. Tumor was lobulated and, in soft parts around it, there was a dense fibrous-tissue reaction. The tendons and the inner parts of the sheaths were free; joint cavities were intact, but filled with a tumor cast. Microscopically, tumor was composed of lobules separated by bands of connective tissue which was quite vascular. In the center of the lobule there was a plexiform mass of poorly formed capillary vessels. In numerous capillaries, endothelial proliferation was shown by stratification of cells and invasion of surrounding tissues. Diagnosis: hemangioblastoma showing evidence of malignancy.

Comment

Angioblastomata of bone are uncommon. This patient is still alive and well over three years since amputation was done, and over four years since commencement of the new growth.—*A. Gibson, M.D., Winnipeg, Canada.*

FRACTURES OF THE EXTENSOR APPARATUS OF THE KNEE. R. Watson Jones. *Canadian Med. Assn. J.*, XXIV, 803, June 1931.

Fracture of the patella. Operation is essential; bone as well as expansion should be sutured; silk is better than catgut or wire; apposition must be very exact; replacement of fragments should be early, and movement should be encouraged from the beginning. Active movement is preferable to passive.

Avulsion of the ligamentum patellae. Use a strand from the thickened anterior margin of the fascia lata, pass it through a transverse tunnel in the apex of the patella, and through a similar one in the tibia, uniting it to itself.

Avulsion of the quadriceps. The vastus internus and the crureus are pulled off from the patella, and within a few weeks new bone may be deposited. This can be avoided by suturing the quadriceps to the bone.

Separation of the tibial tubercle. In early adolescence a small fragment of bone is pulled off from the tibial tubercle. Operative reduction and fixation are necessary. In late adolescence a large fragment, consisting of the tubercle with the greater part of the upper tibial epiphysis, is displaced upward. A pad and back splint are all that is necessary. In the adult fusion is so firm that avulsion by indirect violence is practically unknown.

In all lesions of the extensor apparatus, extensor power must be conserved, but not at the expense of flexion.—*A. Gibson, M.D., Winnipeg, Canada.*

Über die Bedeutung der Schmorlschen Knorpelknötchen und ihren röntgenologischen Nachweis. (Significance of Schmorl's "Knorpelknotchen", and their Rontgenological Demonstration). K. Brandes. *Deutsch. Zeitschr f. Chir.*, CCXXXI, 361, 1931.

In the rontgenographic examination of 240 lateral views of the dorsal and lumbar spine, twelve showed a prolapse of the cartilage. From observations of these twelve cases the author concludes that the possibility of a traumatic origin cannot be disputed; that, however, in the majority of cases the connection with trauma is very doubtful. Complaints are mainly to be ascribed to a fracture or other changes in the spine.—*R. J. Dittrich, M.D., Wichita, Kansas.*

Studies on Effect of Physical Therapeutic Procedures on Function and Structure. (1) Effect on Blood Flow in a Normal Limb. Harold Wolfson. *J. Am. Med. Assn.*, XCVI, 2019, June 13, 1931.

The conflicting clinical report and the small amount of available experimental data concerning the treatment of various conditions by physical therapeutic procedures led the author to carry out some experimental work on dogs for the determination of the actual effect of baking, massage, passive motion, and the different electrical stimulations on the flow of blood in a normal limb, the results being recorded on a drum.

The results automatically fall under two groups. In the first group are those methods which increase the flow of blood to a noticeable degree,—heat, massage, and passive motion. It was found that heat produced an increased blood supply due to active dilatation of the blood vessels; massage and passive motion, by mechanically emptying the blood vessels, caused a temporary increase in the rate of flow.

The second group, which includes all the forms of electrical treatment used, was inconsistent in effecting changes in the rate of flow. If the current had been applied over a longer period of time, the results would have been due to the effect of the heat generated as well as the effect of the current *per se* and one could not then be separated from the other. The value of electricity in the treatment of poliomyelitis and peripheral nerve injuries may be due to some other effects not studied in these experiments.

More frequent but shorter treatments of massage and passive motion are recommended, because nothing is accomplished by the procedure until the vessels have been completely refilled and the new blood allowed time to have accomplished its function.

These observations should be of value as a basis of study of the physiology of the denervated muscle.—*Ruth Jackson, M.D., Dallas, Texas.*

Slipping Ribs: Report of Case. J. Dewey Bisgard. *J. Am. Med. Assn.*, XCVII, 23, July 4, 1931.

Ten cases of slipping rib, or recurring luxation of the lower costal cartilages with abnormal mobility, have been reported. The author presents another typical case of interest, particularly as far as differential diagnosis is concerned, as exemplified by the fruitless laparotomy resulting from a mistaken diagnosis, which inspired Davies-Colley to make his original report.

The symptoms are fairly constant. Radiating pain from the site of the luxating cartilage along the costal or sternal margin, sharp and frequently excruciating pain experienced as the result of lifting, twisting, or flexing the body. A sensation of the "rib jumping out of place", and the appearance of a tender, painful mass along the sternal or costal margin is usually present. Definite tenderness and abnormal mobility of the loose rib cartilage are invariably present. Relief is obtained by lying down, hyperextending the trunk, and by deep breathing in the prone position.

Treatment is resection of the loose terminal portion of the rib cartilage, resulting in complete relief of symptoms. The female sex greatly predominates, but no etiological conclusions can be established.—*Ruth Jackson, M.D., Dallas, Texas.*

RESULTS OF SYMPATHETIC GANGLIONECTOMY AND RAMISECTION FOR CHRONIC ARTHRITIS. James R. Moore. *J. Am. Med. Assn.*, XCVII, 172, July 18, 1931.

This article is of particular interest in that it relates the personal experiences of Dr. Moore who, at the age of thirty-six, developed a progressive arthritis without antecedent illness. Every therapeutic measure known in Egypt and the United States was carried out within a four-year period, with resulting intermittent intervals of improvement followed by progressive increase of joint involvement, local vascular disturbance, and beginning bony changes, until the patient was almost a hopeless cripple.

After a most thorough study of the case a bilateral lumbar sympathetic ganglionectomy and ramisectomy were advised and carried out. Five weeks later patient was able to resume his practice. Six months later the upper extremities were so badly involved that patient requested that a bilateral cervicothoracic sympathetic ganglionectomy and ramisectomy be done. This was followed by prompt relief of symptoms and improvement of the condition.

Dr. Moore would not hesitate to recommend such radical surgical procedures, provided a fair trial has been given other recognized modes of treatment and the indications in the case are that a reasonable result might be obtained.—*Ruth Jackson, M.D., Dallas, Texas.*

DIAGNOSTIC INACCURACY IN TUBERCULOSIS OF BONE, JOINT, AND BURSA. Joseph E. Milgram. *J. Am. Med. Assn.*, XCVII, 232, July 25, 1931.

This paper presents a plea for more accurate diagnosis of tuberculosis of bone, joint, and bursa.

At the University of Iowa the files of the past ten years show 986 cases diagnosed as tuberculosis, 142 of which were diagnosed as tuberculous by the Pathology Department. Of these 142 cases sixty-one and three-tenths per cent. were clinically diagnosed as tuberculosis. Factors concerned in this clinical inaccuracy were: (1) mode of onset, (2) variability of signs, (3) multiplicity of lesions, (4) regional involvement, (5) variability of diagnostic adjuncts, (6) inability to recognize tuberculous lesions in clinically unrecognized cases.

The author concludes that if these patients were to pass through the same institution again, the immediate clinical percentage of diagnosis would be little better, but that extensive resort would be made to pathological and bacteriological examinations and verifications.—*Ruth Jackson, M.D., Dallas, Texas.*

PROPER PLACE OF PHYSICAL THERAPY IN THE TREATMENT OF FRACTURES. Clay Ray Murray. *J. Am. Med. Assn.*, XCVII, 235, July 25, 1931.

The author presents his views concerning the proper place of physical therapy in the treatment of fractures. He advises for maximum results: early reduction, inextensive immobilization in apparatus that will allow the maximum early active use of the part within pain limits, and the use of appropriate physical therapy from the beginning of treatment, the latter consisting of elevation of moderate degree, heat of low intensity over a considerable period of time, massage, and stimulation of the muscles. After the bone lesion has healed, the restoration of function cannot be accomplished by physical therapy alone, but requires active motion within pain limits,—guided active motion; gently resisted active motion; active motion with the patient's mind concentrated on some useful, purposeful aim, rather than on the active motion that he is making.—*Ruth Jackson, M.D., Dallas, Texas.*

TRAUMATIC SHOCK. G. V. Alipoff. *J. Sovremennoi Chir.*, VI, 17, 1931.

The author presents a lengthy discussion of this subject and offers a detailed bibliography. He summarizes his articles with the following conclusions:

1. In many cases shock can be prevented by an early operation performed during the first hours after the injury,—*i.e.*, before a clear picture of shock has made its appearance.

2. The operation must consist of complete débridement of all the injured and contused muscle substance and other tissues. The wound must be closed by sutures and drain inserted or it may even be tightly sutured. An extremity for which there is no hope of salvation should be amputated.

3. The operation must be performed in a minimum space of time, must be bloodless, and sparing of tissues.

4. The best method of operative procedure is that of Crile; local anaesthesia with light ether narcosis should be used.

5. As to postoperative care, the most painstaking attention is needed. All measures known to guard against shock must be applied.

6. In instances where signs of shock already exist and the conservative measures are of no avail, amputation and resection of traumatized muscles is indicated and should be performed in the same manner as stated under 2. During the after-treatment the same preventive care against shock must be rigidly adhered to.

7. Hope must not be lost even in the most severe cases, but operative interference should be instituted.

The author extensively quotes Crile's monograph on surgical shock and highly praises his methods of prevention and treatment.—*A. Gottlieb, M.D., Los Angeles, California.*

DILATATION OF VEINS AS AN INDUSTRIAL DISEASE OF MINE WORKERS. S. Chodkevitsch (Tomsk). *J. Sovremennoi Chir.*, VI, 36, 1931.

Dilatation of veins in miners are of frequent occurrence. Not less than twenty-eight per cent. of all mine workers are affected by some form of venous dilatation,—varicosities of the legs, twenty-two and two-tenths per cent.; hemorrhoids and varicoceles, three and four-tenths per cent. The varicose veins in the legs are usually of second or third degrees and require medical attention. These disease processes are considerably aggravated by some factors due to the environment,—the poison gases, auto-intoxication, localized infections, etc. The high degree of dampness in the atmosphere of the mines contributes largely to the development of diseases of miners; the posture during work also contributes to the disturbance of a normal circulation in the lower extremities. Long years of work in the mines—twenty years or more—give as high as seventy per cent. of workers with varicosities in the lower extremities.—*A. Gottlieb, M.D., Los Angeles, California.*

THIRTY-EIGHT YEARS WITH A FRACTURED SPINE. Douglas Green. *Lancet*, I, 972, May 2, 1931.

In August 1892, a telephone linesman, aged twenty-one, fractured the spine between the eleventh and twelfth dorsal vertebrae. He had a complete transverse lesion; had incontinence and cystitis. He washed out his bladder daily with a weak solution of Condy's fluid. Death occurred in March 1931 through renal insufficiency due to pyelonephritis secondary to cystitis, the man having just reached his sixty-first birthday. —*A. Gibson, M.D., Winnipeg, Canada.*

PERMANENT SEPARATION OF THE EPIPHYSIS FOR THE CAPITELLUM. P. B. Roth. *Lancet*, I, 1346, June 20, 1931.

From the cap of cartilage at the lower end of the humerus the outer half, containing the center of ossification for the capitellum, may be torn away. In two cases recorded, this accident occurred in early life and the part torn off has remained as a separate bone.

Female, aged twenty-two, showed marked cubitus valgus. The left elbow had been broken at the age of four, and had been crooked ever since. The roentgenogram showed that the outer half of the lower end of the humerus was lying separate from the rest of the bone, a considerable gap intervening between it and the remains of the trochlea.

The radius and ulna formed a very oblique angle with the humerus. The function of the elbow is perfect. Pain is complained of in the shoulder; it is suggested that the shoulder pain may be due to commencing osteo-arthritis in the joint, secondary to abnormal strain resulting from the awkward elbow.

Male, aged eighteen, complained of pain in the left elbow when carrying heavy weights. When six years old he had dislocated the joint and had had the dislocation reduced. The roentgenogram showed complete separation of the capitellum from the humerus. The capitellum had been twisted through ninety degrees. There was full movement at the elbow. When the head of the radius rotated, it carried the capitellum with it so that at least part of the movement of rotation took place between capitellum and humerus. Apparently there was a fibrous band joining the capitellum to the humerus.

The correct treatment of such an injury, directly after the accident, is open operation and replacement of the separated fragment by suture. In the cases related above, osteotomy is proposed for the first, and fixation of the fragment for the second.

This is the type of injury which at a later date may produce "late ulnar paralysis".—*A. Gibson, M.D., Winnipeg, Canada.*

Gonococcal Polyarthritis in a New-Born Child. A. D. C. Bell and P. A. Clements. *Lancet*, I, 1349, June 20, 1931.

On the fourth day after birth, a purulent ophthalmia was discovered. On the eighth day it was noted that there was swelling of the middle joints of the left forefinger and the right third finger, which was followed on the next day by a similar condition of the metatarsophalangeal joint of the right great toe, and of the ankle. The organism was identified microscopically and by the complement-fixation test. The patient was discharged practically recovered five weeks later.

Gonococcal arthritis in infants appears to be a rare condition, for the writers have discovered reports on only forty-three cases, and in many of them the causative organism was not identified. The mother's infection was discovered only by the fact that the child developed ophthalmia; this seems to show the importance of careful ante-partum examination.—*A. Gibson, M.D., Winnipeg, Canada.*

A New Bandage for Treatment of Fractures of the Pelvis. E. D. Martin. *New Orleans Med. and Surg. J.*, LXXXIII, 678, April 1931.

A sacro-iliac belt is described, which the author uses in cases of sacro-iliac strain and fractures of the pelvis. The belt is made of either light or heavy canvas five inches in width, reaching from the top of the anterior superior spine to a point below the trochanter major. It is held in place by two one-inch straps buckled in front. An extra strap one and one-half inches wide is run through cleats in the belt just below the crest of the ilium. This is used to take up the slack of the bandage.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

Reliable Method of Tenodesis in a Paralytic Foot. V. D. Tshaklin. *Orthopaedia i Travmatologia*, V-VI, 4, 1930.

A new method of tenodesis is offered by the author. Nineteen cases were operated upon by this method; the first group has been under observation since 1928 and shows a lasting good result.

A preliminary correction of the foot with a tendo-achillis lengthening is performed. Through a longitudinal incision over the anterior surface of the lower third of the leg, the tendons of the tibialis anticus, extensor hallucis longus, and extensor longus digitorum are separated and cut across proximally. The periosteum of the tibia is lifted up and two transverse canals are drilled through the tibia, parallel, and one above the other. The distal part of the tibialis anticus tendon is pulled through the lower canal and

sutured to itself. The extensor communis tendon is pulled through the upper canal and fixed likewise, the tendon of the extensor hallucis longus is sutured to the extensor communis tendon. The periosteum is sutured down.

This method differs from Putti's as described by Erlacher in 1929 in the "Technik des Orthopädischen Eingriffs".—*Emanuel Kaplan, M.D., New York, N. Y.*

Concerning the Question of Hallux Varus Deformity and Late Results of the Hüter-Vreden Operation. E. I. Alexeeva. *Orthopaedia i Travmatologia*, V-VI, 13, 1930.

The author gives a review of 184 cases operated upon between 1910 and 1928.

The procedure of the operation follows:

Curved incision over the medial aspect of the big toe with a proximal base,
Removal of the bursa,
Triangular periosteo-capsular flap with a proximal base,
Removal of the head of the first metatarsal,
Suturing of the periosteo-capsular flap to the base of the proximal phalanx of the big toe.

The author finds this deformity mostly among women between fifteen and thirty years; she considers that the wearing of improper shoes and the transverso-planus deformity are mostly responsible for hallux valgus.

She also finds that the operation radically improves the deformity, rids the patient of pain, and is very effective as far as mobility of the toe is concerned. However, it weakens the ligamentous apparatus of the foot and favors the development of a transverso-planus deformity—*Emanuel Kaplan, M.D., New York, N. Y.*

Plastic Reconstruction of the Patella. N. V. Novoseltsev. *Orthopaedia i Travmatologia*, V-VI, 71, 1930.

On operating for a tumor of the patella, the author was compelled to excise the patella. Fearing the usual complications, he worked out the following procedure for anatomic reconstruction which he used with considerable success: The first incision was made over the patella and the patella removed. The second incision was made below the tibial tuberosity, over the anterior surface of the leg, down to the bone. An oval piece of bone was shaped out and excised from the tibia. A third incision was made on the lateral surface of the thigh on the same side, the fascia lata exposed, and a piece eighteen by six centimeters cut with a distal pedicle; the fascia lata flap was then passed under the skin into the first incision, and then used to cover the gap in the capsule and to envelop the oval piece of bone. The quadriceps tendon was sutured and the skin closed in the usual manner.—*Emanuel Kaplan, M.D., New York, N. Y.*

Free Transplantation of the Calcaneus for Weight-bearing Stump in Amputation of the Thigh. R. N. Bakushinsky. *Orthopaedia i Travmatologia*, V-VI, 85, 1930.

Intending to perform a Gritti-Stokes amputation, the author found upon exposure of the knee, that the patella was too atrophied for use. In order to cover the cut surface of the femur, he excised the posterior half of the calcaneus and, after reshaping, sutured it to the periosteum of the femur. The author uses an instrument of his own invention, facilitating the preparation of the patella for attachment to the femur in the Gritti-Stokes operation.—*Emanuel Kaplan, M.D., New York, N. Y.*

X-ray Treatment of Bone Metastasis. Cassie B. Rose. *Radiology*, XVI, 536, Apr. 1931.

In the author's experience with fifty cases of metastatic carcinoma in bone, while there has been no cure, there has been marked relief from pain, prolongation of life,

and often a considerable period of ability to return to business activity. There has been, in many of the cases, considerable regeneration of bone destroyed by the metastasis. Details are given of six cases, with their roentgenograms before and after radiation.—*Edward N. Reed, M.D., Santa Monica, California.*

ENDOTHELIAL MYELOMA OR EWING'S SARCOMA. William B. Coley. *Radiology*, XVI, 627, May 1931.

While these tumors form a much smaller group than the osteogenetic sarcomata, this group is of special interest because most of the recoveries of bone sarcomata fall within it. Originating mostly in the shafts of long bones, in children or young adults, these tumors belong in a separate classification because of distinctive clinical, roentgenologic, and histologic characteristics. They are highly radiosensative, this indicating which tumors may be treated conservatively and which require immediate amputation. They are also very sensitive to the toxins of erysipelas and bacillus prodigiosus.

Clinical characteristics are: (1) location in shaft of long bone; (2) antecedent local trauma, in about fifty per cent.; (3) rapid development; (4) early pain, worse at night and often referred some distance from the site of the tumor; (5) occurrence in childhood or youth; (6) softer than osteogenetic tumor; (7) involving a considerable portion of the shaft; (8) early metastases to neighboring glands or bones; (9) local heat and often general rise in temperature; (10) pathological fracture in later stages. Roentgenologically there is destruction of all the layers of the shaft, a thickening of the shaft, moth-eaten in appearance, without new bone formation.

The differential diagnosis from osteomyelitis is difficult. In case this differentiation cannot be made, the case should be treated as endothelial myeloma.

Differentiation from benign tumors: the benign tumor is more sharply localized; is less diffuse; is of long duration, and painless; never involves soft tissues; never metastasizes to glands or viscera; may be bone-forming or bone-destroying.

Differentiation from osteogenic sarcoma: this tumor has the same percentage of antecedent trauma, also early pain, often referred some distance. However, osteogenic sarcoma usually begins at the end of the bone, in the diaphysis; beginning in the periosteum or subperiosteum, it quickly involves the center of the bone, without destroying the layer of the cortex. It is usually pear-shaped, tapering toward the mid-shaft. The periosteum is lifted along the shaft at the line of the advancing tumor. The osteogenic sarcoma is harder than an endothelial myeloma. The myeloma is often laminated in structure, while in osteogenic sarcoma the new bone is often arranged in spicules, at right angles to the long axis of the bone.

The untreated Ewing's tumor is the most malignant of bone tumors.

Where the diagnosis is in doubt, the author believes biopsy should be done. When myeloma is diagnosed, treatment should be with radiation and Coley's toxins; if osteogenic sarcoma, immediate amputation should be done. Frozen sections may be inconclusive and the author considers it justifiable to wait for paraffin sections. The aspiration method of diagnosis is satisfactory in the myeloma type, making biopsy usually unnecessary.

Surgery alone shows very poor results in treatment of myeloma. Thirty-four cases treated by radiation alone gave only one five-year cure.

Twenty cases treated with toxins alone, or toxins and surgery, gave twelve cures of five to twenty-two years' duration. Four of these twelve were inoperable when treatment was begun, three having metastases.

Thirty-two cases treated with toxins and radiation gave nine cures of from five to thirteen years, five of which were inoperable when treatment was begun, three having metastases.

The conclusion seems justified that conservative treatment, for a limited period, with Coley's toxins combined with local radiation, should be instituted. If there is not marked improvement in six or eight weeks, then amputation (or resection), followed by prolonged toxin treatment, should be considered.

It is not justifiable to attempt to save a limb by toxins or radiation in the presence of osteogenic sarcoma. Immediate amputation should be done.

The author believes that endothelial myeloma is of microbic origin.—*Edward N. Reed, M.D., Santa Monica, California.*

OSTEITIS FIBROSA. Frederic J. Cotton. *Radiology*, XVI, 657, May 1931.

This may occur: as multiple bone involvement; as single bone involvement, expansion with little change in density but with disappearance of the marrow cavity; as cysts near the ends of the bone, with or without other bone involvement; as lesions resembling Ewing's tumor or the non-suppurative osteomyelitis of Garrè (these latter always post-traumatic); and as osteitis fibrosa of the small bones,—Köhler's disease, Preiser's disease, Kienböck's disease, and the rest.

There is no characteristic pathological picture of osteitis fibrosa. A similar microscopic appearance obtains in Paget's disease, or near a staphylococcic bone infection, and in the repair tissue following giant-cell growths.

The author believes that there is no such disease as osteitis fibrosa; but that fibrosis in bone, with concomitant changes, is merely the reaction of bone to various stimuli.

He thinks these cases should be operated upon, both to avoid mistaken diagnosis, and because of the benefit of operation in relieving intra-osseous tension, and in removal of excessive bone.

An absolute line between osteitis fibrosa and Paget's disease cannot be drawn: Paget's disease begins, typically, in the early fifties; osteitis fibrosa, in younger persons. Paget's disease is apt to be bilateral. Between the fibrous repair of a giant-cell tumor or a cyst, and osteitis fibrosa, the differential diagnosis is difficult; as also between osteitis fibrosa and a non-suppurative osteomyelitis.—*Edward N. Reed, M.D., Santa Monica, California.*

FIFTH LUMBAR VERTEBRA ROENTGENOLOGICALLY DEMONSTRATED. Webster W. Belden. *Radiology*, XVI, 905, June 1931.

Describes the anatomy of the fifth lumbar vertebra, and its anomalies.

The commonest congenital anomaly is sacralization of the transverse processes, one or both. The next most common is narrowing of the transverse process, or narrowing with upward tilting. Next comes failure of fusion of the laminae of the spinous process, considered by some to be an incomplete spina bifida. Variations in size, position, or angle of the articular facets are common.

In regard to pathological changes: If the vertebral bodies are involved and the intervertebral discs are clear, this is pathognomonic of malignant disease. If the intervertebral disc is destroyed, this is due to injury or infection, malignant disease never involving the cartilage.

The rarest disease attacking the fifth lumbar vertebra is tuberculosis. Osteomyelitis is also rare. Osteitis deformans is frequent, and osteitis fibrosa cystica may be found here, as may osteomalacia.

Malignant disease may be osteoclastic, with destruction of the body but not of the intervertebral cartilage; or osteoplastic, with no destruction but increased density of the body.

The author has never encountered sarcoma involving the fifth lumbar vertebra. The disease most frequently involving this bone is hypertrophic osteo-arthritis.

Because of its position and surroundings, fractures of the body of this vertebra are rare and caused usually by severe direct violence, with the exception of an occasional compression fracture. Its most frequent injury is fracture of the transverse process.

The author states emphatically that he has never seen a subluxation of the sacro-iliac joint, except associated with a fracture, and does not believe it occurs without fracture. Moreover, the diagnosis of disease of a sacro-iliac joint by x-ray is a very doubtful procedure.

In the writer's opinion one of the most frequent causes of low back pain, is spondylolisthesis. This may occur in children as young as seven years. It may be associated with congenital anomalies, or with a history of trauma, or with both anomalies and trauma. It is as frequent in the normal or locking type of articular process as in the non-locking, abnormal type. The weight is not borne on the articular processes, but on the vertebral bodies.

The fifth lumbar is predisposed to this forward slipping on the sacrum by the inclination of the superior surface of the sacrum and by the fact that this joint forms the union between the relatively fixed foundation of the pelvis and the mobile spine, at which the strains of lifting and twisting are concentrated.

The stability of the articulation between sacrum and fifth lumbar vertebra has been sacrificed in order to allow some rotation here. The most important union between sacrum and fifth lumbar vertebra is formed by the intervertebral disc, and the elastic interspinal and interlamellar ligaments. Normally the sacrum is built out under the fifth lumbar vertebra, tending to prevent it from sliding off.

The author feels that backache cannot be accounted for by x-ray demonstration of anatomic variations from the accepted normal standard. These variations are very frequent in patients who have no low back pain. Patients whose x-rays show a definite spondylolisthesis may be entirely free from pain. The determination of the cause of backache from x-ray examination can be made only in case of fracture or disease.—*Edward N. Reed, M.D., Santa Monica, California.*

The Treatment of Compressed and Impacted Fractures of the Bodies of the Vertebrae. John Dunlop and Carl H. Parker. *Radiology*, XVII, 228, Aug. 1931.

This paper describes the method of reduction of compressed fractures of the bodies of the vertebrae originated by the author in 1927. It reports the results in thirty cases. The method is used only in cases from which cord symptoms are absent; and in which the injury is limited to the body of a vertebra.

Under general anaesthesia, traction and countertraction are made by four assistants, pulling on each ankle and on sheets crossed beneath the shoulders. With the patient lying on his back, a sheet is folded to eight inches' width and passed beneath the injured segment. By means of this the operator and assistant toss the patient upward and catch his weight, while in hyperextension, strong traction being maintained throughout the manoeuver. The patient is then placed in strong hyperextension on a Goldthwait frame and a plaster cast applied, in which he remains usually four months. He is never turned face down while in the cast.

This radical treatment of compression fracture is considered necessary, since less radical treatment gives a percentage of permanent disability in about every case, ranging from ten per cent. up.

Practically all of the authors' cases have shown satisfactory reduction, and none have developed any evidence of cord injury.—*Edward N. Reed, M.D., Santa Monica, California.*

Syphilitic Arthritis. E. S. Hatch. *Southern Med. J.*, XXIV, 471, June 1931.

He agrees with Nichols that fifty per cent. of cases of latent bone syphilis give negative Wassermann reactions. He depends more on the skiagraphic picture than anything else. Campbell found that eighty-eight per cent. of his cases gave positive Wassermann reactions.

Skiagrams show a definite periostitis, new bone laid down parallel to the shaft; in some cases the Codman blister is seen. Cortical thickening is seen. A lace-work type of periostitis is also seen. Definite small punched-out areas are quite common on the surfaces of bones entering into joints. Localized sharply pointed hypertrophic changes are frequently seen; osteomyelitis or degenerative changes, also osteoporosis. Syphilitic arthritis may exist without any demonstrable bone changes.

Family history and marital history must be carefully considered. We frequently see cases of painless, joint swelling, often bilateral, especially in the knees. Pain, if any, is usually worse at night. He quotes Alan H. Todd:

"Bilateral painless hydrops of the knees in children is due to syphilis. Never diagnose rheumatism in any form until syphilis has been excluded as a possibility in the diagnosis. Never diagnose tuberculosis or any other form of arthritis until you have excluded syphilis. Monarticular arthritis of a deforming type at any age, with or without pyrexia, may be due to syphilis."

Numerous case histories with skiagrams follow.

Conclusions: (1) Syphilitic arthritis is much more common than is generally believed. (2) Always suspect syphilis in all cases of arthritis that cannot be definitely diagnosed. (3) Do not place too much credence in a negative Wassermann. (4) Have skiagraphs of tibia and fibula made in suspected cases. (5) Give anti-syphilitic treatment as a therapeutic test in suspected cases.—*F. G. Hodgson, M.D., Atlanta, Georgia.*

A New (Plaster Yoke) Dressing for Fracture of the Clavicle. R. Wallace Billington. *Southern Med. J.*, XXIV, 667, Aug. 1931.

He discusses the well known objections to other methods of treatment and claims that the advantages of the plaster yoke are: It is rigid and does not slip or change its shape; thus holding the position as when applied. It will positively and continuously hold the shoulder upward and backward and sufficiently outward. It permits positive downward pressure by felt pads on the outer end of the proximal fragment. It allows free use of both arms and hands. It is comfortable in both the erect and the recumbent positions. It does not cause pressure on vessels or nerves. It gives better results than other methods. It is not difficult to supply. Materials used are simple and inexpensive.

Technique. Padding consists of a strip of saddler's felt, one-quarter to three-eighths inches thick, by three to six inches wide, long enough to make a posterior figure-of-eight of the shoulders. This is threaded through stockinette of appropriate width to prevent skin irritation. Cotton batting may be used but is not as satisfactory. A few plaster-of-Paris bandages, three or four inches wide, are needed. The dressing may be applied with patient sitting in chair or recumbent with head and shoulders over the end of a table. The patient is fixed by bandages or held by a strong assistant. The affected shoulder is held by an assistant upward, backward, and outward, the arm in about sixty degrees' abduction. The patient holds the opposite arm in about the same position. The padding is applied in a snug figure-of-eight and should cover the proximal fragment an inch or two. The plaster bandages are applied by figure-of-eight turns with extra layers to reenforce the yoke portion. The dressing should be just heavy enough to be rigid. The edge of the padding should extend beyond the plaster. The cast is trimmed under the arm to one or two inches in width. While setting, it should be carefully molded around the base of the neck and under the arms. It is not simply a figure-of-eight bandage but a true yoke.—*F. G. Hodgson, M.D., Atlanta, Georgia.*

The Radical Cure of Hallux Valgus (Bunion). A. L. Soresi. *Surg. Gynec. Obstet.*, LII, 776, 1931.

The author describes an operation for hallux valgus in which a subperiosteal and subarticular resection of the head of the metatarsal bone is done. The head and shaft of the first metatarsal bone is exposed by an incision on the medial side of the foot. The periosteum is then split from the middle of the shaft to one-quarter inch of the articular surface of the head and the periosteum loosened about the shaft. The articular surface with some bone is detached from the shaft and sufficient bone removed from the shaft to allow the toe to be straightened. The bursa and excess skin are removed.

The advantages claimed for the operation relate to the preservation of the joint, the realignment of the joint, and the possibility of employing the operation even when the bursa has been previously infected and is not suitable for an intra-articular flap as employed in the Mayo operation.—*Hugh T. Jones, M.D., Los Angeles, California.*

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